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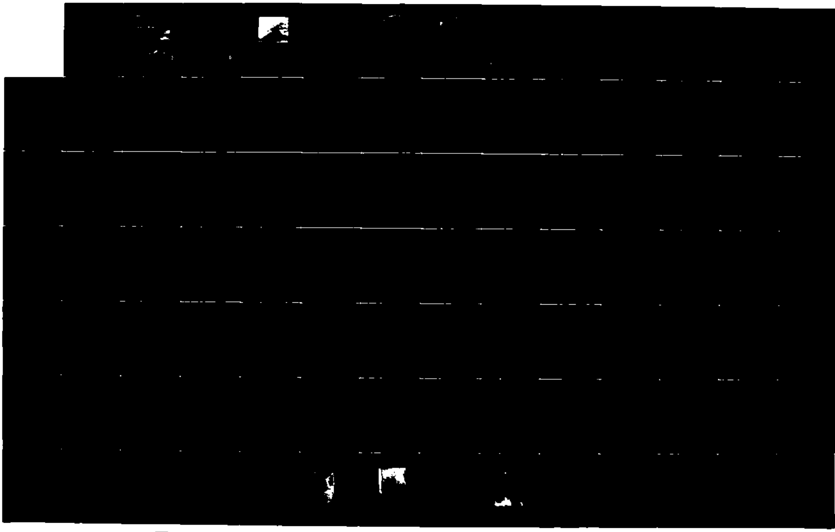

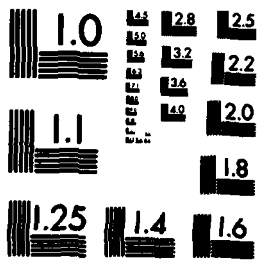

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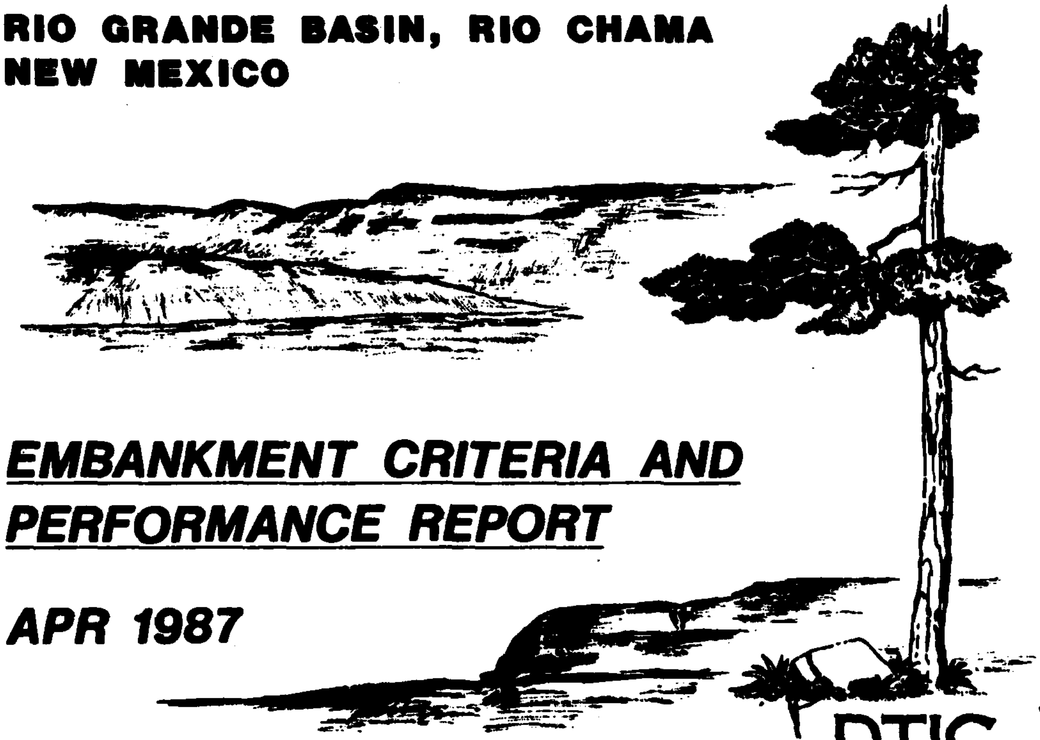
US Army Corps
of Engineers
Albuquerque District

ABIQUIU DAM AND RESERVOIR

RIO GRANDE BASIN, RIO CHAMA
NEW MEXICO



EMBANKMENT CRITERIA AND PERFORMANCE REPORT

APR 1987

PREPARED BY
U.S. ARMY ENGINEER DISTRICT, TULSA
CORPS OF ENGINEERS
TULSA, OKLAHOMA

ABIQUIU DAM AND RESERVOIR
RIO GRANDE BASIN, RIO CHAMA, NEW MEXICO

EMBANKMENT CRITERIA AND PERFORMANCE REPORT

PREPARED FOR U.S. ARMY ENGINEER DISTRICT, ALBUQUERQUE
CORPS OF ENGINEERS
ALBUQUERQUE, NEW MEXICO

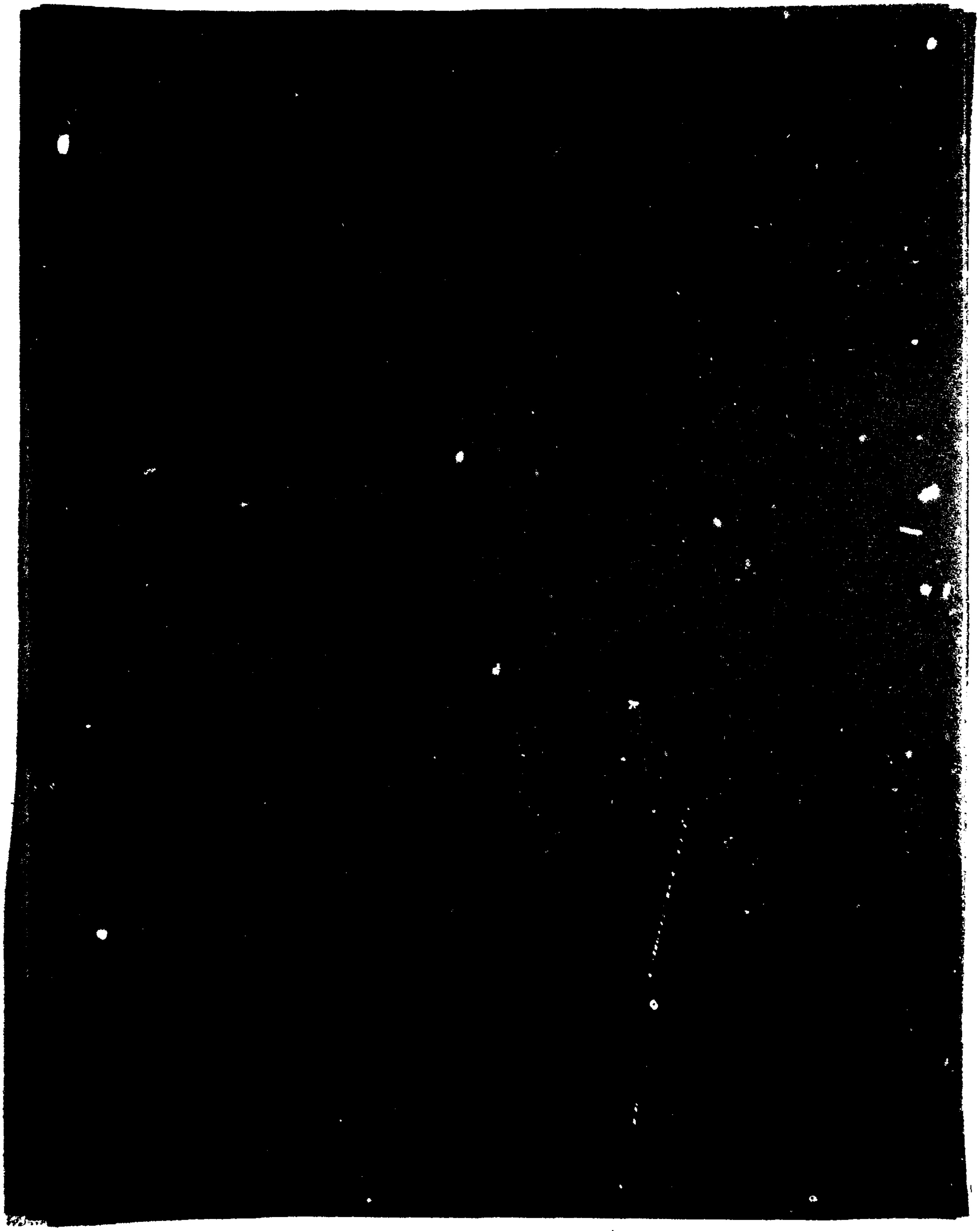
BY U.S. ARMY ENGINEER DISTRICT, TULSA
CORPS OF ENGINEERS
TULSA, OKLAHOMA

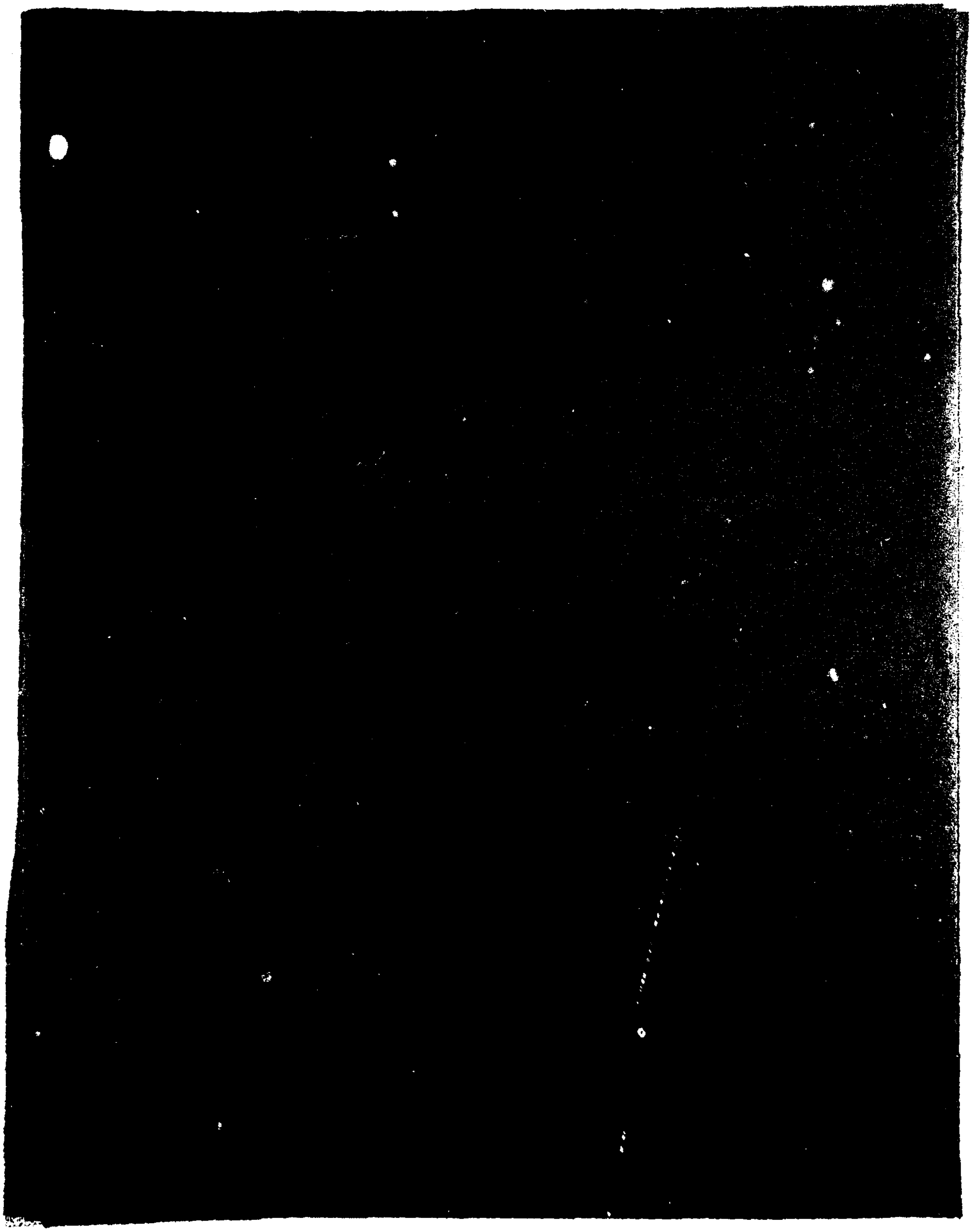
April 1987

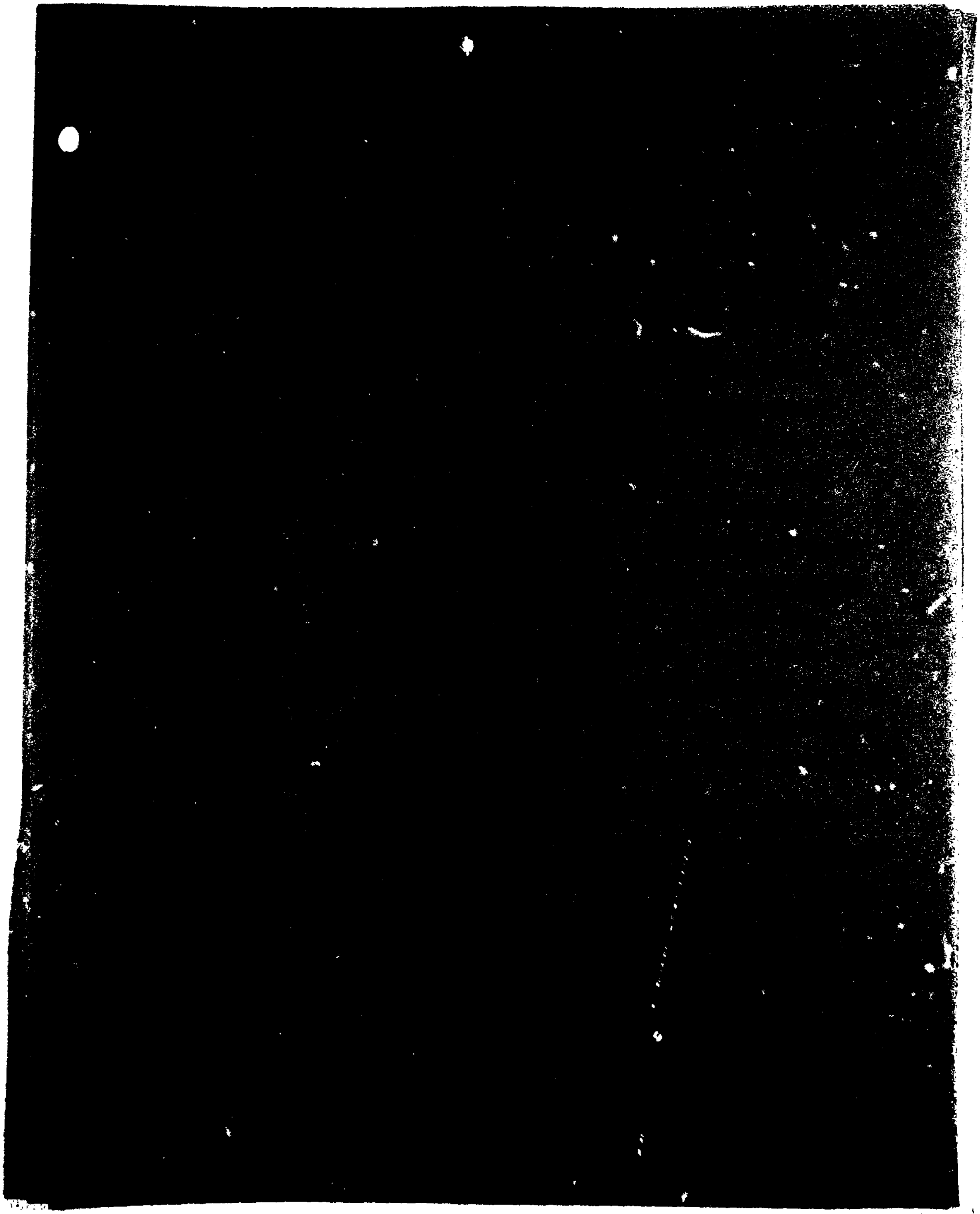
Frontispiece

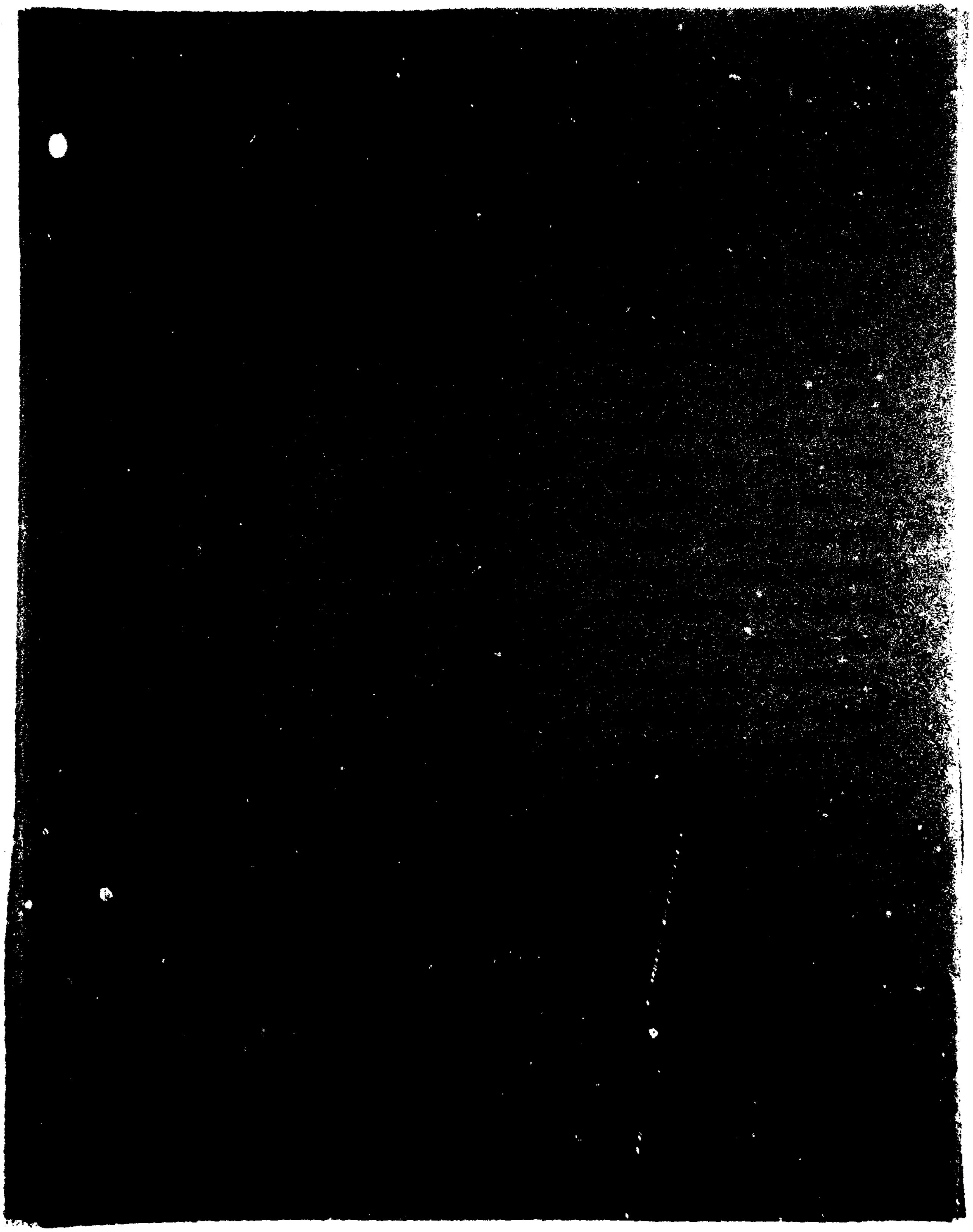
FOREWARD

This report was prepared by Tulsa District personnel under the direction of Weldon M. Gamel, Chief, Engineering Division. Colonel Franklin T. Tilton, was District Commander during the time that the report was being prepared, and Colonel Frank M. Patete was the District Commander at the time it was published.









ABIQUIU DAM AND RESERVOIR

RIO GRANDE BASIN, RIO CHAMA, NEW MEXICO

EMBANKMENT CRITERIA AND PERFORMANCE REPORT

PERTINENT DATA

1. General Data.

LOCATION: Rio Arriba County, New Mexico, on the Rio Chama at river mile 33.

PURPOSE: Flood and sediment control

AUTHORITY: Flood Control Act of 30 June 1948, Public Law 80-858, and Flood Control Act of 17 May 1950.

2. Reservoir Data.

a. Drainage Area ---------------------------- 2,146 sq. miles

b. Pool elevations, ft N.G.V.D.

Maximum pool elevation -------------------- 6,362.0

Top of flood control pool ----------------- 6,283.5

c. Areas, acres

Maximum pool ---------------------------- 13,834

Top of flood control pool ---------------- 7,469

d. Capacities, acre feet

Maximum pool	1,369,000
Top of flood control pool	565,000
Sediment reserve	63,000

3. Dam.

Crest elevation	6,368.0
Crest length, ft	1,540.0
Crest width, ft	30.0
Maximum height above stream bed, ft.	325.0
Freeboard, ft.	6.0
Type	compacted zoned earthfill

4. Spillway.

Location -------- off-channel, emptying into Rio Chama from left bank just below outlet works

Type ------------ uncontrolled, rock-cut

Crest elevation	6,350
Bottom width, ft	40
Design discharge, c.f.s.	7,800
Surcharge, ft.	12

5. Outlet Works.

Type ---------------------------	Controlled tunnel
Control ------------------------	Two 5x9-foot hydraulic operated service gates
Conduit diameter, ft --------------------------	12
Discharge at top of dam elev., c.f.s. ---------	8,100
Discharge at maximum pool elev., c.f.s. -------	8,000
Discharge at spillway crest elev., c.f.s. -----	7,800
Discharge at flood control pool elev., c.f.s. -	6,900

c

EMBANKMENT CRITERIA AND PERFORMANCE REPORT

PART I - GENERAL

1. Purpose and Scope. ER 1110-2-1901, dated 31 December 1981 outlines the need for and scope of embankment reports and authorizes their preparation for all new earth and earth-rockfill construction projects, and for existing projects where significant remedial treatment, project complexity or approaching obsolescence make it desirable to have such reports. Abiquiu Dam is a project which has had significant post construction remedial treatment. This report will provide in one volume the significant information needed by engineers to (1) familiarize themselves with the project, (2) re-evaluate the embankment in the event unsatisfactory performance occurs, and (3) provide guidance for designing comparable future projects. Included in this report is a summary of design data, design assumptions, computations, specification requirements, construction data, field control and record control test data, and embankment performance as monitored by instrumentation.

2. Authorization and Purpose of Project. Abiquiu Dam and Reservoir was authorized for construction by the Flood Control Act of 1948, approved 30 June 1948, (Public Law No. 858, 80th Congress, Chapter 771, 2nd session) and the Flood Control Act of 1950 approved 17 May 1950 (Public Law No. 516, 81st Congress, Chapter 188, 2nd Session). The purpose of the project is to control the runoff from the upper portion of the Rio Chama. Under the plan of reservoir regulation set forth under Title II, Flood Control, Section 201, Rio Grande Basin, Public Law 86-645, approved 14 July 1960, permanent storage of water was not authorized.

3. Location of Project. Abiquiu Dam is located across the Rio Chama, approximately 30 miles upstream from its confluence with the Rio Grande, in Rio Arriba County, New Mexico. The dam is approximately 30 miles northwest of Espanola, 50 miles south of Chama, and 60 miles northwest of Santa Fe, New Mexico.

4. Project Description. The project consists of an earthfill dam, a separate uncontrolled spillway, a tunnel outlet with gates, intake structure, and flip bucket, and administrative facilities for operation and maintenance of the project. These project components are shown on plate 1 and described as follows:

a. Dam. Abiquiu Dam is a rolled earthfill structure with a maximum height of 325 feet and crest length of 1540 feet. The crest width is 30 feet and is paved to accommodate New Mexico State Highway 96. The embankment contains a central impervious core and cutoff trench extending through the alluvial stream bed material to firm rock, flanked by upstream and downstream random fill zones. A 10-foot thick horizontal blanket of pervious material extends from the downstream toe of the impervious core to the downstream toe of the embankment. A 10-foot thick inclined filter blanket of pervious material separates the impervious core and downstream random fill zone. A 2-foot thickness of dumped rock covers the entire downstream slope except at the service road. The downstream slope varies from 1 on 2.851 to 1 on 3. A service road extends diagonally back and forth across the downstream slope to provide access to the downstream toe area. The upstream slope has an outer pervious zone above elevation 6190, covered with a 6-foot thickness of dumped rock. A required waste fill berm below elevation 6190 and an optional waste fill berm up to elevation

6200 protect the upstream toe of the embankment. Plates 2 and 3 show a profile and typical sections of the embankment. The structure was recently modified under the Dam Safety Assurance Program by raising the embankment crest to elevation 6,382.3 and widening the spillway to 68 feet.

b. Outlet Works. The outlet works consist of the intake channel, intake structure, tunnel, gate chamber and access shaft, flip bucket, and the outlet channel. Plate 4 shows the layout of these features. The intake structure, shown on plate 5 and located on the left abutment, has two intake passages equipped with trash bars, bulkhead slots, and a low stage floatwell. The trash bars are constructed of reinforced concrete. The tunnel is a 12-foot diameter reinforced concrete conduit with an overall length of 2,235 feet. The tunnel was bored through shale and sandstone of the left abutment with invert elevations of 6060 and 6050 at the upstream and downstream ends respectively. Plate 6 shows details of the tunnel. At the gate location the tunnel transitions to two parallel 5-foot by 9-foot rectangular conduits for the two service gates, with provision for two future emergency gates. The gate chamber provides room for the operation and maintenance of the service gates and the future emergency gates. The gate chamber is a 16-foot high cylinder of 36 feet inside diameter with a hemispherical dome cover of 18-foot radius. In the center of the dome is the 16-foot diameter opening for the vertical access shaft. The access shaft extends for a distance of 281.5 feet above the top of the gate chamber. The shaft permits removal of gate operating equipment and houses the elevator, emergency exit ladders, air vents, high stage floatwell, ventilation duct, hoistwell guides, and miscellaneous piping. Plates 7, 8, and 9 show the access shaft, gate chamber, and mechanical equipment in the gate chamber. The flip bucket, located

at the downstream end of the tunnel, is designed to divert the high velocity flow away from the end of the structure and to disperse the flow over the river bottom. Plate 10 shows grading plan and sections of the flip bucket. Plate 11 shows the plan and section of the concrete.

c. Spillway. The uncontrolled spillway is located in a natural saddle approximately 4,000 feet north of the left abutment. The 3,000 foot long spillway was originally constructed with a crest elevation of 6,350, a minimum bottom width of 40 feet, and a maximum depth of about 42 feet, excavated in sandstone. Plate 12 shows the location of the spillway and details of the original construction. The spillway was recently modified under the Dam Safety Assurance Program to increase the peak discharge capacity of the spillway from 7,800 c.f.s. to 30,800 c.f.s. This was accomplished by widening the spillway from the original width of 40 feet to 68 feet, without lowering the crest elevation. The spillway discharges into the Rio Chama streambed about 1,000 feet below the dam.

d. Reservoir. Abiquiu Reservoir covers an area of 7,470 acres at top of flood control pool, elevation 6,283.5, and 12,600 acres at spillway crest, elevation 6,350.0. The lake created at flood control pool is about 5 miles long and 2 miles wide at the widest point. Under the plan of reservoir regulation set forth under Title II-Flood Control, Section 201, Rio Grande Basin, Public Law 86-645, approved 14 July 1960, permanent storage of water was not authorized. However, in October of 1967 the Rio Grand Compact Commission approved the establishment of a permanent pool of 2000 acre feet to improve trap efficiency and to increase sediment retention. Storage began on 6 March 1968 and the

project was operated with 2000 acre feet of sediment storage pool until December 1973. An increase in the sediment storage pool to 4000 acre feet was approved in December 1973. A contract with the city of Albuquerque was consummated in 1974 for storage of trans-mountain water in the remaining sediment storage space. Storage of city water began in mid December of 1974. The reservoir was drained in January 1976 to install bulkhead gates and remained empty through March. Considerable sediment that had been deposited in the reservoir was carried downstream while the reservoir was empty. The pool has been approved for 15,000 acre feet of permanent storage since April 1976. In December 1981 Public Law 97-140 authorized up to 200,000 acre feet of storage of San Juan-Chama water.

e. Administrative Facilities. The administrative facilities at the project consist of an operations building, well house, comfort station, overlook shelter, and operator's quarters. The operations building is located over the access shaft to the operating gallery and contains a shop area, an administrative wing, and a storage wing. The operator's quarters consist of two residences located about 600 feet northwest of the operations building. A permanent standby diesel engine generating set is located in the operations building to provide power for the operation of the project during periods of failure of the primary power supply.

5. Construction History. Construction of Abiquiu Dam began in 1956 and was completed in 1963. The contract for construction of the outlet works was awarded to A.H. Horner Construction Company, and Mid Valley Utility Constructors, Inc. on 10 August 1956. Work under this contract included the intake structure, the flip bucket, the tunnel, and the access shaft and operating gallery. The

contract for the embankment and spillway was awarded to Mittery Construction Company on 26 February 1959. Contruction was begun in March 1959 and was completed in February 1963. Other pertinent contracts included a contract to Ishmael Trujillo General Contractor on 2 October 1959 for construction of operator's quarters and miscellaneous facilities and a contract to New Mexico State Highway Department on 16 July 1959 for relocation of portions of U.S. Highway 84. Modifications to the project have been provided since original construction was completed which include Contract CIVEN-29-003-66-43, to Continental Drilling, Los Angeles, CA, in 1966 for Grouting; Contract 77-C-0039, Abutment and Embankment Piezometers, Abiquiu; Contract 78-C-0044, Slope Stabilization at Intake Structure, Abiquiu Dam; Contract 78-C-0047, Supplemental Grouting and Drainage System, Abiquiu; and contract 79-C-0086, Supplemental Grouting, Increment II, Abiquiu. Contract 85-C-0035 (NEG), Dam Safety Assurance Modifications, was awarded to J.A.R. Concrete, 9609 Carnegie Ave, El Paso, TX, to modify the embankment and spillway to accomodate the PMF without overtopping the dam. Work started 22 May 1985, and was completed in September 1986.

PART II - SUBSURFACE INVESTIGATIONS

6. General. The present site was investigated by a drilling program that included 44 core holes, 3 fishtail holes, and 3 holes for the borehole camera. The locations of these holes are shown on Plate 13. Graphic logs of these holes are shown on plates 14 through 18. Borrow areas were investigated using 216 power auger holes, 43 test pits, and 7 fishtail holes. Plate 19 shows the location of the borrow areas and the holes and test pits. Selected samples obtained from these borrow area investigations were tested to determine mechanical analysis, Atterberg limits, field moisture, and soils classification. Summaries of test results are shown on Tables 1 through 3.

7. Borrow Areas B-1, B-2, and B-3. Borrow area B-1 is located on the right bank of Rio Chama from about 3/4 mile upstream of the embankment to about 2-1/2 miles upstream. The borrow area is from 1/2 mile to 1 mile wide. Approximately 134 power auger holes and 35 test pits were sampled to obtain data on the quantity and engineering properties of the various materials within the borrow area. Borrow area B-2 is located on the left bank of Rio Chama between 1 and 1-1/2 miles upstream of the embankment. This borrow area is approximately 1/2 mile or less in width. Twenty-one power auger borings and 8 test pits were sampled and tested to identify the properties of materials within this area. Borrow area B-3 is located on the left abutment from about 1/2 to 1-1/2 miles from the embankment. This area is about 1/2 mile wide. The spillway is located near the center of the area. Sixty-one power auger holes were drilled in the overburden of this area and were sampled and tested in the laboratory. An upstream extension of borrow area B-1 was investigated from about 2-1/2 miles upstream of

the embankment to about 4 miles upstream. This area was investigated with 71 power auger borings and 5 fishtail borings. Although this area was investigated it was not shown as a borrow area on the contract plans.

8. Spillway and Outlet Works Areas. Three core holes were drilled in the spillway area to investigate the nature of the rock in the area. Graphic logs of these three holes and a geologic section along the spillway are shown on plate 15. Fourteen core holes, three fishtail holes, and one borehole camera hole were drilled along the alignment of the outlet works facilities. Graphic logs of these holes and a geologic section along the outlet works alignment are shown on plate 14.

9. Embankment Foundation Areas. Twenty-seven core holes and 2 holes for the borehole camera were drilled in the foundation for the embankment to determine the pertinent engineering characteristic of the foundation materials at the site. Plate 13 shows the location of these borings. Plates 15 through 18 show the graphic logs of these borings and a geologic section along the axis of the dam.

PART III - SITE GEOLOGY

10. General. The close of the Cretaceous Period culminated in wide spread crustal movements that have caused a mosaic of fault blocks, erosion and penoplanation, and deposition of approximately 2000 feet of sediments. Additional deformational crustal adjustments near the close of the Tertiary Period uplifted and faulted the region outlining the broader features of the present day topography. Quaternary time brought long periods of erosion interrupted by vulcanism. Successive piedmonts and broad valleys were incised, and in turn dissected, leading finally to the modern floodplain, especially in the reservoir area. The dam is located in a narrow, deep canyon approximately 350 feet deep, varying in width from about 300 feet at the bottom to about 1500 feet at the top. The upper rim of the canyon is the Poleo Sandstone of Triassic age. The Poleo Sandstone is underlain at the site by the Abo formation of Permian age.

11. Poleo Formation. Rock of the Poleo Sandstone is dominantly white to buff colored, medium to coarse grained, quartzitic, well cemented, and highly jointed. Locally there are thin seams and zones of conglomerate with cobbles up to four inches in diameter. All sand and gravel size material is well rounded. Reddish-brown mudstone occurs as irregular lenses and seams.

12. Abo Formation. The Abo formation of Permian age unconformably underlies the Poleo Sandstone. The upper part is a massive, red to brown mudstone with irregular lenses and masses of gray green sandy mudstone. The remainder of the Abo exposed at the dam site is a series of interfingering lenses of silty

mudstone and silty sandstone. The dominant color is red-brown, but some units are purple to green. Individual beds vary horizontally in both thickness and composition. The sandstones are extensively jointed and the mudstones display numerous minor joints. Joint faces in the mudstone are commonly striated and slickensided and at random orientation.

13. Faulting. A fault was exposed during excavation on the south abutment. This fault is pre-Triassic age. Due to limited exposure it was not possible to determine the strike and dip of this fault or the amount of the displacement. The general trend of the fault plane is northwest and the dip is about 45 degrees to the northeast. Movement appeared to be normal and the minor drag developed in the hanging wall side supports the assumption of a normal fault. Pre-Triassic erosion reduced all relief across the fault and the Poleo Sandstone overlies the fault with no visible offset. No evidence of post-Triassic faulting was observed within the damsite. The topographic restriction utilized for the dam is the result of high angle normal faulting during the Cenozoic. The dam is located on a horst block bounded by north-south trending faults. The upstream fault crosses the Chama about one quarter mile upstream from the intake portal and the downstream fault crosses the Chama about a half mile below the downstream toe of the embankment. The Chama River has incised its channel through the upthrown fault block while eroding a large basin in the softer rocks of the down faulted block yielding a large reservoir area.

14. Overburden Materials. The overburden of the abutments varied in thickness from 0 to as much as 90 feet, and also varied from a thin mantle of residual soil to a highly pervious heterogeneous mixture, containing rocks and rock fragments

in a matrix of sandy clay. The rocky portion of the mixture ranged in size from very large sandstone boulders down to sand and gravel size fragments. On the left abutment the overburden attained a thickness of 90 feet because of a combination of talus accumulation and slumping. The average thickness of overburden under the embankment was 40 feet. On the right abutment overburden was much thinner, the average being about 10 feet. The cutoff trench extended through the river alluvium and 5 feet into the primary formation. Overburden was removed from the abutments within the area of the embankment to eliminate the possibility of large differential settlement. A cutoff trench was excavated a minimum of 5 feet into the primary formations of the abutment.

15. Borrow Areas. Soils of the borrow areas along the river consisted of terrace gravel overlain by a variable thickness of fine-grained material. The fine-grained material was a mixture of eolian, slope wash, and fluvial materials. Selective borrow excavation produced the required types of fill material without additional processing. The fine-grained material yielded core material with a minimum of 40 percent passing the 200 sieve, generally in the sandy clay (CL) and clayey sand (SC) range, while the gravels yielded pervious fill with less than 8 percent minus 200 material. Borrow was obtained from three locations. Borrow area B-1 was along the right bank of Rio Chama upstream from the damsite. Borrow area B-2 was along the left bank of Rio Chama upstream of the damsite. Borrow area B-3 was located in the spillway area north of the left abutment. Soils in borrow area B-3 consisted typically of fine-grained overburden underlain by the abutment sandstone formation.

PART IV -- FOUNDATION TREATMENT

16. Intake Structure. During excavation for the intake structure a small slide developed on the north side of the structure. Approximately 2,300 cubic yards of material were involved and the entire mass was removed during the excavation. After excavation to grade, a protective concrete backfill was placed to prevent deterioration of the mudstone. The mudstone was generally resistant to air slaking when exposed for short periods but failed rapidly when saturated. The extreme southwest corner of the wingwall is resting on river cobbles and the remainder of the structure is bedded on red to maroon, clayey to silty mudstone. The river cobbles are well rounded and are composed dominantly of quartzite. The mudstones were excavated by drilling and blasting to rough grade, followed by final grading using air-powered tools and hand labor. The exposed surfaces were cleaned of all loose material prior to placing of concrete. The mudstone exposed at final grade was firm, fresh bedrock and was believed to be an adequate foundation for the structure. In 1973, and again in 1975, movement occurred in the talus slope to the north of the intake structure. This movement did not affect the intake structure but destroyed 600 feet of service road and all previously installed measuring points were lost. A contract for slope stabilization in this area was awarded in FY 78. Plate 20 through 27 show the area involved and the extent of remedial work performed.

17. Tunnel. The 2235 foot long tunnel was excavated between about 15 and 16 feet in diameter to provide a final 12 foot inside diameter, concrete lined tunnel. A short entry was made at the upstream portal and then the tunnel was driven through to the upstream entry from the downstream portal. Drilling was

done by jumbo-mounted percussion air drills. Mucking was done by a pneumatic overshot mucker, and diesel motor side dump cars were used to haul the muck. Water was encountered in the tunnel from station 15+04B to 17+26B and 20+38B to 20+86B. The water entered the tunnel excavation at the base of a thick conglomerate. Attempts to seal off the water by grouting were unsuccessful, so tunneling operations were continued using additional blocking and lagging to prevent fallout. During the summer of 1957, the flow was measured to be an average of 1000 gallons per day. Throughout most of the tunnel the rock is a reddish to maroon, blocky to massive, silty mudstone with indistinct bedding planes. Where the mudstones were exposed to constant wetting in the seepage area of the tunnel they failed by slaking, resulting in fallout and considerable overbreak. The opening of joints in the fresh, firm bedrock of the tunnel was believed to be due to disturbance of stress conditions during and following excavation. The grouting program was believed to be effective in sealing these fractures. The grouting consisted of contact grouting, to fill the voids between the liner and the rock, followed by consolidation grouting. Very little grout take was achieved by the consolidation grouting, indicating that the contact grouting had filled the joints and fractures very effectively.

18. Flip Bucket. Initial excavation was completed in the flip bucket area prior to beginning of tunnel excavation. When final excavation was begun, rough grading was accomplished by drilling and blasting and use of power equipment. The key ways were drilled and blasted and final shaping was by hand methods. Line drilling, specified for much of the excavation, was impractical because the material was conglomerate that was not well cemented. Excavation between stations 28+30B and 29+10B, for the placement of derrick stone, was done by

drilling and blasting and the use of power equipment. To the north (left) of the French drain, installed 85 feet south of the centerline of the flip bucket for water supply, the excavation bottomed in maroon mudstones. To the south of the French drain the excavation was in recent stream gravels and cobbles. The French drain was backfilled with selected pervious fill. The bottom of the drain is entirely within stream laid gravels and sand.

19. Access Shaft and Gate Chamber. The 16 foot diameter access shaft was excavated from the ground surface down to a depth of 287 feet (elevation 6114.0). The structural steel supports and tight lagging and blocking were installed as excavation proceeded. The upper two-thirds of the shaft penetrated sandstones with thin mudstone layers and the lower one-third penetrated mudstones with thin sandstone layers. Concrete placing commenced at elevation 6118.0 and proceeded up to the surface of the ground. Excavation of the gate chamber progressed from the back of the transition section up to elevation 6114.0 and tied into the lower end of the access shaft. Considerable fallout of the sandstone occurred in the upper part of the shaft. The sandstone is extensively jointed and the blocks thus formed fell out unless supported by tight lagging and blocking. Some of the joints were open and showed evidence of ground water percolation. The lower portion of the shaft was sunk in distorted clays with many slickensided masses ranging from the size of a baseball to as large as 30 cubic feet. This material was very unstable. When pressure was relieved, by continuation of the shaft excavation, immediate steps had to be taken to block the face in place. In spite of these efforts the greatest overbreak of the job occurred in this reach of the shaft. The lower portion of the shaft was protected by pneumatically placed mortar and extensive blocking, which was

successful in preventing further deterioration of the mudstones. At elevation 6111.7 the weakest rock of the entire project was encountered, which consisted of a black, organic mud about 6 feet thick. This material would not suppport itself when excavated, and 8-foot long roof bolts would not hold. The presence of open and extensive joints in the sandstones in the upper two-thirds of the shaft indicated that significant leakage could be expected to occur during high pool conditions.

20. Spillway. The spillway was excavated in the Poleo sandstone of the left abutment. No special treatment of the sandstone was required to maintain stability of the excavated faces.

21. Abutments. Overburden on the left abutment varied in thickness from 0 to about 90 feet in a large slump area immediately downstream of the axis. The depth of overburden on the right abutment varied from about 5 to 35 feet. The overburden was an unconsolidated mass of small to very large angular sandstone boulders intermingled with residue of erosion of the parent sandstone, shale, clay and siltstone formations. Since the abutment overburden was not considered suitable foundation for the earth embankment it was removed within the limits of the compacted fill. A large overrun in excavation unclassified occurred in stripping of abutments to suitable foundation material. The contract volume was 1,750,000 cubic yards. The final pay was for 3,412,000 cubic yards. The major overrun in excavation unclassified was on the right abutment. The area and height of the upstream waste fill berm were increased to provide a disposal area for part of the overrun volume. The remainder was wasted in designated spoil areas. The foundation area of the impervious core on abutment bedrock received a

minimum 2-inch thickness of pneumatically placed mortar to prevent slaking of foundation material and to seal open fractures, cracks, joints, and bedding planes.

22. Embankment. In the streambed area, the cutoff trench was excavated to bedrock to provide a water tight bond. The streambed outside the core area was excavated to an elevation of 6050 upstream and 6045 downstream of the core zone to remove unsatisfactory material. The downstream rock fill toe was placed in a trench excavated to bedrock. A single line grout curtain was constructed along the axis of the dam.

PART V -- EMBANKMENT

23. General Description. The embankment is a rolled earthfill structure with a maximum height above the streambed of 325 feet. The crest length is 1540 feet and has a 30 foot wide paved crest carrying State Highway 96. A service road traverses back and forth across the downstream slope to the downstream toe area. The downstream slope varies from 1 on 2.851 to 1 on 3. The upstream slope is 1 on 4 from a waste berm at elevation 6200 to the crest at elevation 6368.0. Plate 13 shows a plan view of the embankment.

24. Embankment Zoning. The embankment is zoned to obtain maximum benefit from the construction materials available at the site. A central impervious core extends through the alluvial streambed deposits to firm rock. The impervious core is 10 feet wide at elevation 6365 and extends downward at 1V on 0.5H slopes upstream and downstream to the overburden contact. At that point the excavation through the overburden is sloped 1V to 1.5H to the firm rock line. The abutment overburden was removed and the contact of the impervious core with the abutments was excavated a minimum of 1 foot into the primary foundation material to provide a good contact. Overhangs and ledges were removed to prevent differential settlement. A 10-foot thick inclined filter of pervious material was placed adjacent to the downstream slope of the impervious core. A 10-foot thick horizontal blanket of the same material was placed over the overburden material from the downstream toe of the impervious core to the downstream toe of the embankment. A rock fill toe was placed at the downstream toe of the embankment from elevation 6059 to the top of rock in the toe area. This rock fill toe consisted of 1 foot of graded filter material, 2 feet of riprap, and 7 feet of

derrick stone. The remainder of the downstream slope consisted of a random fill zone covered by a 10 foot horizontal thickness of pervious fill and a 2-foot thickness of dumped rock. The upstream embankment consists of a random fill zone, a pervious fill zone above elevation 6190 covered by a 6-foot thickness of dumped rock, a required waste fill berm below elevation 6190, and an optional waste fill berm to elevation 6200. Plates 2 and 3 show typical sections of the embankment, as originally constructed. In 1985 a contract was awarded to raise the embankment crest and widen the spillway. Plates 50 and 51 show the modification to the embankment.

25. Embankment Crest. The 30-foot wide crest consisted originally of a cap of impervious fill overlain by a 6-inch thickness of gravel surfacing material and a single bituminous surface treatment. A 2-inch thick plant mix surface was added subsequently. An Armco bin-type retaining wall was constructed at the right abutment crest to accommodate a horizontal curve in the road across the embankment. This bin wall was subsequently covered with a rockfill section to assure stability of the roadway. Two feet of camber was provided to accommodate the anticipated 50 year settlement of the embankment. In 1985 a contract was awarded to J.A.R. Concrete, El Paso, Texas, to raise the top of dam to elevation 6382.3 to prevent overtopping by the PMF determined using latest criteria. This work was completed in September 1986.

26. Slope Protection. The downstream slope of the embankment is protected from erosion by a 2-foot thick layer of dumped stone, overlying a pervious fill zone of 10 foot horizontal thickness. A rock toe consisting of 1 foot of graded filter material, 2 feet of riprap, and 7 feet of derrick stone protects the

downstream toe from erosion. Above elevation 6190, the upstream slope is protected from wave wash erosion by a 6-foot thickness of dumped rock over a pervious fill zone. Below elevation 6190 a berm of waste fill protects the upstream toe of the embankment from erosion. The waste fill came from abutment overburden excavation. The dumped stone slope protection consists of sandstone from the spillway excavation.

27. Embankment Materials. Embankment materials came primarily from the borrow areas in the alluvial valley upstream of the embankment. The upper material consisted of fine-grained deposits suitable for the impervious portion of the embankment and the underlying material consisted of clean gravel which was suitable for the pervious fill zones. The embankment fill quantities actually used were as follows:

Material	Quantity (Cu. yd.)
Impervious fill	1,840,000
Pervious fill	1,710,000
Random fill	7,860,000
Total	11,410,000

Material for the impervious fill was required to have at least 40 percent fines. Pervious fill was required to have not more than 8 percent fines. Maximum size of stone allowed was 4 inches in the impervious fill, and 6 inches in the pervious and random fill zones.

28. Fill Placement. Moisture contents of materials in the upstream borrow area were well below optimum, which made it desirable for the contractor to use a unique system of excavation, transportation, and moisture control for embankment materials. Borrow excavation was accomplished with a wheel-type excavator having a capacity of 2,000 to 3,600 cu. yd. per hour. The material was hauled in bottom-dump units to the loading hopper of a 4,300 foot belt conveyor system. A vibrating scalper removed oversize material as the borrow material was fed onto the belt conveyor. The belt discharged the material into a receiving hopper located near the embankment area. Water was automatically injected into the borrow material as it was discharged into bottom-dump units for the short haul to the embankment. Supplemental watering and additional mixing was seldom necessary for the fill. The impervious fill was placed in 9-inch loose lifts, the random in 12-inch lifts, and the pervious in 18-inch lifts. In the impervious fill the moisture content was required to be between 1 percent dry of optimum to 2 percent wet of optimum water content. After compaction the impervious fill had an average moisture content of 12.3 percent, which was about 1.8 percent below the average associated optimum moisture content. The random fill was required to be between 3 percent dry of optimum and optimum. The average moisture content of compacted random fill was 10 percent, which was about 2.1 percent below the average associated optimum water content.

29. Fill Compaction. The embankment fill was compacted with four passes of a 50-ton rubber tired roller. The average density of the compacted impervious and random fill zones was 97 percent of the standard density. Additional rolling for compaction was not required in any area.

30. Field Control Tests. Field control tests on impervious and pervious materials showed an average percent fines of 51 and 4.4 percent respectively. Table 4 gives a summary of design, construction-control, and record sample data for embankment and foundation materials.

31. Borrow Area B-1. Borrow area B-1 was the major source of embankment fill material and was the source of the pit-run pervious material. This area, shown on Plate 19, was expected to yield approximately 8,900,000 cubic yards of fine-grained overburden suitable for impervious or random fill and approximately 2,000,000 cubic yards of pit-run sand and gravel suitable for pervious fill. An additional 1,800,000 cubic yards of pit-run sand and gravel were available upstream of borrow area B-1. This material had an excessive amount of fines for pervious fill but would have been suitable for the random fill zone. The fine-grained material from borrow area B-1 generally classified as sandy clay (CL) and clayey sand (SC). The pit-run gravel was classified as a clean, well to poorly graded sandy gravel (GW or GP), or in the upstream borrow area extension, as well to poorly graded sandy gravel (GP-GM, GW-GM, or GM). The length of haul from borrow area B-1 varied from about 0.8 to 2.7 miles.

32. Borrow Area B-2. Borrow area B-2, located on the left bank of Rio Chama upstream of the embankment, was estimated to contain approximately 1,100,000 cubic yards of fine-grained overburden suitable for random fill. The fine-grained overburden was generally classified as sandy clay (CL). The pit-run sand and gravel was generally classified as sandy gravel (GP, GW, GP-GM, or GC). Because of excessive fines in the pit-run sand and gravel, this area was not

suitable as a source for pervious fill material. Haul distance from this area ranged from 0.9 to 1.5 miles.

33. Borrow Area B-3. Exclusive of the spillway and access road right-of-way this borrow area would provide approximately 1,900,000 cubic yards of overburden suitable for impervious or random fill. The overburden was generally classified as sandy clay (CL) with areas of silty sand (SM), clayey sand (SC), and clayey sandy gravel (GC). Borrow area B-3 was located above elevation 6300 on the left abutment. The haul distance varied from 0.5 to 1.5 miles.

34. Embankment Materials from Spillway Channel. Construction of the spillway required excavation of approximately 41,000 cubic yards of overburden and 87,000 cubic yards of sandstone rock. The overburden was typical of borrow available from borrow area B-3 and was used in the impervious and random fill zones of the embankment. The sandstone was used for dumped rock slope protection.

35. Embankment Materials from Outlet Works. No information was available to determine whether materials excavated in conjunction with the construction of the outlet works were used in the embankment.

36. Structure Backfill. No information was available to determine the source of the material used to backfill around the structures.

37. Discharge Channel. No information was available to show where the materials excavated from the discharge channel were utilized in the construction.

38. Required Waste Fill. A waste fill berm was required to be placed as shown on Plates 1, 3 and 13.. The material for this waste fill came from excavation of abutment overburden. The material was placed in 36-inch layers with no compaction other than the incidental compaction from hauling and spreading equipment. The foundation of the waste fill berm was not stripped, as was the foundation under the compacted fill portion of the embankment. A required waste fill dike was also constructed on the left abutment as shown by Plate 13.

39. Waste Fill. Because of the large overrun in excavation unclassified that occurred from stripping the abutments to suitable foundation material, additional waste areas were required. An optional waste fill berm was provided that extended upstream of the required waste fill berm and also extended from elevation 6190 to 6200. This optional waste fill berm is shown on plates 1, 3 and 13. Material for this berm came from the abutment stripping operation, and was placed in 36-inch layers without compaction other than by hauling and spreading equipment.

PART VI -- STABILITY ANALYSIS

40. Methods of Stability Analysis. The embankment stability was analyzed during design using the Swedish Slice Method of slope stability analysis, modified to permit graphical determination of normal and tangential forces. However, as required by DAEN-CWE-S letter dated 13 August 1976 and 2nd ind to Periodic Inspection Report No. 1 dated 28 July 1971, a reevaluation of embankment stability was performed. A GE 225 computer was used to locate critical arcs, using the Simplified Bishop Method of Stability Analyses, as discussed in Geotechnique, Vol. V, No. 1, p. 7, March 1955. The critical arcs thus determined were checked manually by use of the Modified Swedish Method of Slope Stability Analysis as presented in EM 1110-2-1902, "Engineering and Design, Stability of Earth and Rockfill Dams," dated 1 April 1970.

41. Design Assumptions for Stability Analysis. Detailed stability analyses were limited to the streambed area of the alignment. Preliminary studies of the abutment sections indicated a less critical condition due to decreased height of embankment fill, stripping of the abutments to undisturbed primary formation, and presence in the primary formation of strata of sandstone and conglomerate which would effectively limit the depth of assumed failure surfaces into the abutment foundation material. The stream bed primary formation is quite complex with the more competent siltstones and sandstones and the weaker clays and shales being discontinuous and variable in thickness and extent. Because of the discontinuity of the more competent foundation materials in the streambed area, trial failure arcs for stability analyses were permitted to penetrate the primary formation to elevation 5990, approximately 55 feet below streambed elevation. The bend of the

canyon upstream from the axis of the dam, as shown by plate 1, is such that the waste fill berm at elevation 6190 fills the canyon and effectively reduces the height of the embankment for stability analyses. The berm was sized so that any streambed section of the embankment, taken perpendicular to the axis, does not intersect the 1 on 5 waste fill slope from elevation 6190 to streambed level. Drawdown for analysis of the upstream embankment slope was assumed to elevation 6190. Earthquake forces were not considered in the preliminary design analyses. However, in the reevaluation studies a seismic coefficient of 0.1 was used.

42. Shear Strength Data for Stability Analyses. Shear strength values obtained by testing samples of abutment and streambed primary formation materials and the design shear strength values selected for the original design studies are shown on plate 28. Shear test values and selected design strengths for impervious and random fill materials used for original design studies are shown on plate 28A. The minimum shear strength as defined by the combined envelope of consolidated-drained and consolidated-undrained shear curves, as shown on plate 28A, were used for stability analyses of the sudden drawdown condition. The combined CD-CU envelope was also used for analyses of the construction case instead of unconsolidated-undrained shear strength because of the expected permeability of 1×10^{-6} feet per minute for compacted impervious and random fill. Although the characteristics of the impervious and random materials are very similar, different shear strengths were selected for design based on considerations of field placement moisture. Drained shear strengths, for impervious, random, and pervious borrow material were based on strength values determined by consolidated-drained direct shear and triaxial compression tests. Shear strength values used for reevaluation of embankment stability were determined

from record samples taken during construction for the impervious and random fills, and during design for the foundation materials. The shear strengths used during design were conservative in that 100 percent of the undisturbed and record sample test values exceeded the design strengths selected. Plate 29 shows strength values used in the reevaluation studies.

43. Stability Analyses for Construction Condition.

a. Design Studies. The analyses of embankment stability for the construction condition are presented in DM No. 7 for the original design. Plate 30 shows a summary of the arcs investigated and the assumptions used in the analyses. The construction condition was defined as the condition at the end of a 3-year construction period before any pore pressure induced during placement of random and impervious fill had time to dissipate. Tailwater elevation was assumed to be streambed level with no seepage through the embankment. The combined CD-CU shear strength envelope was used for trial arcs cutting the random fill 10 feet or more above the pervious stream bed blanket. A factor of safety of 1.22 was determined for the critical arc.

b. Reevaluation Studies. The construction case was not reevaluated since conditions assumed for this case were no longer applicable. Post construction stability was reevaluated for the steady seepage case and the steady seepage case with earthquake forces.

44. Stability Analyses for Sudden Drawdown Conditions.

a. Design Studies.

(1) Drawdown from Maximum Water Surface. Full saturation of the embankment was assumed to elevation 6283.5, the invert of the proposed uncontrolled outlet, with partial saturation of the random fill section from elevation 6283.5 to maximum water surface elevation 6362. The partial saturation was based on routing studies of spillway design flood and the time element of temporary storage above elevation 6283.5. The drawdown of the reservoir pool was from elevation 6362 to elevation 6190, top of the waste fill berm. The dumped rock slope protection and the pervious fill were cons iered to be free-draining. No drainage was assumed for the random and impervious fill sections. Submerged unit weights were used for material below elevation 6190. A factor of safety of 1.18 was determined for the critical failure arc. Plate 31 shows detailed analysis of the critical arc and factors of safety for other trial arcs.

(2) Drawdown from Spillway Crest. Full saturation of the embankment was assumed to spillway crest elevation 6350 with drawdown to elevation 6190, top of the waste fill berm. Drainage assumptions and unit weights were the same as for analysis of drawdown from maximum water surface. A factor of safety of 1.05 was determined for the critical arc. Detailed analysis of the critical arc and factors of safety of other trial failure arcs are shown on Plate 32.

b. Reevaluation Studies. Sudden drawdown from the maximum water surface to the top of the waste fill berm was considered the most critical condition and was

the condition used in the analysis. The pervious shell was considered to be free draining. The piezometric level for the upstream random fill zone and the impervious core zone was developed from flow net analyses presented in DM No. 7. The streambed alluvium, random fill below elevation 6190 for arcs 7, 8, and 9, primary formation, and waste fill were considered submerged. For the computer solution, the random fill was considered to be the average of "R" and "S" strengths. For the manual solution "R" and "S" strengths were used as specified in EM 1110-2-1902. The computer solution, using the Simplified Bishop Method, gave a safety factor of 1.92 for the critical arc. The manual solution, using the Modified Swedish Method, gave a safety factor of 2.05 for the critical arc. Stability analyses for both solutions are summarized on plates 33 and 34.

45. Stability Analyses for Partial Pool Condition.

a. Design Studies. The upstream slope was analyzed for static pool elevations of 6190, 6230, 6270, 6310 and 6350. Shear strengths determined by consolidated-drained tests were used in the analyses. The critical arc, as determined for a past construction condition with no pool, was analyzed for the variable pool elevations. The lowest factor of safety was 1.64 at a pool elevation of 6250. Details of the analysis for the critical arc and variation of safety factor with pool elevations are shown on plate 35.

b. Reevaluation Studies. The partial pool condition was not reevaluated using current methods and criteria.

46. Stability Analyses for Steady Seepage Condition.

a. Design Studies. The downstream slope was analyzed for the post construction condition with steady seepage during original design studies. It was found that the seepage forces through the embankment and foundation have only a minor effect on stability of the downstream embankment slope. Plate 36 shows a flow net for the steady seepage condition for the pool at elevation 6350 (spillway crest). The inclined pervious fill chimney drain and the horizontal blanket drain effectively control the position of the seepage line in the embankment. Drained shear strengths were used for all embankment and foundation materials. The critical arc for this condition had a safety factor of 1.39. Details of the analysis for the critical arc and safety factors for other trial failure arcs are shown on plate 36.

b. Reevaluation Studies. For the reevaluation studies the steady seepage condition was analyzed with the pool at elevation 6283.5 (flood control pool). For the computer solution the random fill was considered to have a shear strength of ("R" + "S")/2, whereas, for the manual solution the random fill strength was represented by zones of "S" and ("R" + "S")/2, as outlined by EM 1110-2-1902. The piezometric level in the downstream random fill zone was estimated from the rise in measured piezometric levels during the 1973 flood. The minimum safety factor for the computer solution was 1.73, as compared to 1.69 obtained by the manual solution for the critical arc. Stability analyses are summrized on plates 37 and 38 for the two methods.

47. Stability Analysis for Earthquake with Steady Seepage. When stability of the embankment was reevaluated, analyses were performed to evaluate the effect of earthquake induced forces on stability of the embankment. Since Abiquiu Dam is located in the moderate seismic probability zone 2, a seismic coefficient of 0.1 was assumed. Three solutions were obtained, one computer and two manual, with the pool at elevation 6283.5 (flood control pool). One manual analysis was performed with the critical arc obtained from the computer analyses and the other was performed with the critical arc obtained from the steady seepage analysis. The minimum factor of safety for the computer solution was 1.04 for the earthquake arc and 1.12 for the steady seepage arc. This compared to a factor of safety of 1.12 and 1.15, respectively, for the manual solutions. Stability analyses for the three conditions are summarized on plates 39, 40, and 41.

48. Evaluation of Seismic Stability. In addition to reevaluation of embankment stability using current criteria a more comprehensive appraisal of seismic stability was performed, as requested by OCE. This appraisal showed that the embankment materials consist of sandy clays and coarse sands and gravels compacted to a high density. Foundation materials are bedrock and coarse alluvial sands and gravels. These materials are not believed to be susceptible to liquefaction and are expected to be competent under cyclic loading. In January 1971, a magnitude 4.7 (Intensity VI) earthquake was recorded over a 600 sq. mi. area of the Albuquerque, N.M. region. Again in December 1971, a magnitude 3.2 (Intensity V) earthquake was recorded near Abiquiu, N.M. During the earthquake, intensity IV was recorded at the Abiquiu Damsite. No visible deformation or other instability was noted after these earthquakes were felt and recorded. The pseudo dynamic analysis performed in the stability reevaluation is

considered conservative, since the Abiquiu Damsite is near the border between zones 1 and 2 and the seismic coeeficient of 0.1 for zone 2 was selected. The factor of safety of 1.12 obtained by this analysis is greater than the minimum required. Additionally, the relatively large freeboard between flood control pool and top of dam provides a greater margin of safety against earthquake induced deformations. Because of these circumstances the use of a pseudo dynamic analysis is considered adequate and a more comprehensive dynamic analysis is not justified.

PART VII - SEEPAGE AND SEEPAGE CONTROL

49. General. Investigations were performed during preliminary design studies to determine the seepage or leakage characteristics of the abutment and foundation materials. The formations at the site consist of Poleo sandstone, of Triassic age, and the Abo sandstone of Permian age. The formations containing salt and gypsum are absent from the immediate vicinity of the dam. The water table slopes gently toward the river, indicating that no loss of impounded water from the basin would be expected.

50. Permeability of Foundation Materials. The more indurated strata within a formation show more intense deformational joints, while the more plastic portions show poorly developed or no jointing. Numerous vertical or highly inclined joint planes are generally confined to individual strata and stop at bedding planes. This condition represented the most likely source of seepage and leakage through the abutments and foundations. During investigations hole 9, in the south abutment, lost circulation at 89.9 feet, 93.6 feet, and at 176.2 feet of depth. The hole accepted water beyond the 60 g.p.m. capacity of the pump at these depths without creating a hydrostatic head in the hole. Hole 9A, drilled 10 feet from hole 9, lost circulation at 85 feet. Over a three day period 140,000 gallons of water were pumped into hole 9A without raising the water level or appearing on the abutment slope. Hole 6, in the north abutment, lost circulation at 81.0 feet. A total of 55,000 gallons of water was pumped into the hole in 6 hours time without raising the water level or causing any water to emerge on the abutment slope. On the other hand, formations below the river alluvium were found to be tight, based on pressure tests performed in drill holes. The

overburden varied from a thin mantle of residual soil to a highly pervious heterogeneous mixture which contained all sizes of rocks up to 15-foot angular sandstone boulders.

51. Seepage Control Features. The abutments were stripped for the full embankment width and a cutoff trench was excavated 5 feet into the primary formation. The streambed alluvium was removed to rock under the impervious zone, and a minimum of 1 foot of rock was removed. A single line grout curtain was installed along the dam axis to minimize seepage through the primary formation of the foundation. A 10-foot wide zone of pervious fill was placed downstream of the impervious zone, a 10-foot thick horizontal blanket was placed over the streambed alluvium from the downstream toe of the impervious core to the downstream toe of the embankment, and a 10-foot thick blanket of pervious fill was placed against the abutments downstream of the impervious core. A 10-foot wide blanket of pervious material was placed over the downstream slope of the downstream random fill zone, tieing into the abutment blankets, the inclined pervious fill blanket, and the horizontal pervious blanket. These zones or blankets of pervious fill were installed to intercept and remove all seepage from the embankment or abutments and prevent saturation of the downstream random zone.

52. Impervious Core Zone. The impervious core zone was constructed of selected impervious material from borrow areas B-1, B-2, and B-3. The material was required to have at least 40 percent, by weight, of soil sizes passing a standard No. 200 sieve. The moisture content of the impervious material was required to be between 2 percent above and 1 percent below optimum. The coefficient of permeability of the impervious borrow, when compacted to construction density,

was expected to be in the range of $1x10^{-6}$ to $1x10^{-8}$ feet per minute.

53. Inclined Pervious Chimney. The inclined pervious chimney was constructed of selected free-draining pit-run sand and gravel obtained from natural deposits in borrow area B-1 and from required excavation in the streambed alluvium. Material was required to be free of objectionable coating and have not more than eight percent, by weight, passing the standard No. 200 sieve.

54. Cutoff and Inspection Trench. Excavation for the cutoff trench in the streambed area was made initially through the alluvial streambed materials to the primary formation. After completion of foundation drilling and grouting, finish excavation was made a minimum of 1 foot into the primary formation, followed immediately by placement of impervious fill. Slush grouting was performed to fill cracks and voids in the foundation where necessary. The foundation in the abutments was excavated 1 foot into the undisturbed primary formation above elevation 6025. The entire abutment contact of the impervious core between elevations 6025 and 6365 received pneumatically placed mortar or was slush grouted to fill cracks and to prevent slaking of the foundation material when exposed.

55. Foundation Bedrock. The foundation bedrock below streambed elevation was found to be relatively tight and impervious. Rock in the abutments was found to be relatively pervious, based on borings made during design, leakage experienced during construction of the outlet works access shaft and tunnel, and leakage experienced since the pool was impounded. The extent of the leakage necessitated additional grouting in the abutments and a system of drains and drain holes at

the base of the abutments to control the seepage.

56. Grout Curtain. A single line grout curtain was constructed along the axis of the embankment from station 3+00A to 21+00A as a part of the original construction contract. Plate 15 shows the extent of this initial grout curtain. Grouting was performed from the surface after completion of preliminary excavation to the approximate grade. Conventional stage grouting procedures were followed. Zone 1 extended from the surface to 20 feet, zone 2 from 20 to 50 feet, zone 3 from 50 to 90 feet, and zone 4 from 90 to 140 feet or bottom of the hole where a greater depth was required. Each hole was drilled to full depth of the particular stage being grouted unless a significant loss of drilling water occurred. If drill water was lost drilling was stopped and the hole grouted. Several holes were drilled and grouted to successive stages as a unit to facilitate observation of washing and pressure testing and placement of grout. Primary grout holes were spaced at 40 foot centers in the streambed and at 20 foot centers on the abutments. Quantities of grout placed varied greatly from hole to hole. Irregular zones of permeable material were encountered within the Abo formation. Most of the grout placed in the Poleo sandstone served to fill the open fractures in the sandstone. A total of 39,753 sacks of cement was placed in 22,476 feet of grout hole during this phase of the grouting work. Plate 42 shows the location of these grout holes and the quantities of grout placed. During 1966 supplemental grouting was performed. Work included drilling and grouting 110 holes in the left abutment, installing horizontal drain holes and installation of 14 piezometers, and drilling and grouting 16 holes in the area surrounding the control shaft. Supplemental grouting was later performed in both abutments to reduce the amount of leakage through the abutments and to lower

the piezometric levels within the abutments. Plate 43 shows the location of these extended lines of grout curtain. Supplemental drilling and grouting were performed during 1966 in an attempt to reduce seepage around the control shaft and through the left abutment. Sixteen holes were drilled around the control shaft to an elevation of 6115 feet. A total of 4480 linear feet of hole was drilled and grouted, and 2317.5 cubic feet of cement were placed for an average of 0.52 cubic feet per foot drilled. Seepage into the control shaft was almost eliminated by this program. A 560-foot section of embankment was regrouted from Station 9+50A to 3+90A and a 500-foot section of grout curtain was added on the left abutment. A total of 50,659.5 cubic feet of cement were pumped into 49,486 linear feet of drill hole for an average of 1.02 cubic feet per foot drilled. Details of this program may be found in Supplemental Grouting, April 1967, U.S. Army Engineer District, Albuquerque, New Mexico. The second increment of supplemental grouting was performed under contract No. 78-C-0047 and extended from station 0+00S(19+80A) to 5+00S in the right abutment and from 17+60A to 19+80A in the embankment foundation. Details of this grouting are shown on plate 44. A third increment of grouting was performed under contract No. 79-C-0086 extending from 5+00S to 10+00S and from 5+00G to 10+00G on the right and left abutments respectively. Plate 45 shows details of this stage of the grouting.

57. Estimated Seepage Quantities. During construction of the outlet tunnel water was encountered at a rate of up to 1000 gallons per day. Seepage from the left abutment of up to approximately 2.0 c.f.s. was measured in August of 1965, shortly after impoundment. Gate chamber leakage of up to approximately 1250 gallons per hour was also measured during this period. The first increment of supplemental grouting, performed in 1966, reduced the gate chamber leakage to

practically nothing and reduced the left abutment leakage from 0.9 c.f.s to 0.3 c.f.s.

58. Internal Drainage and Pressure Relief Features. In addition to the pervious chimney drain and horizontal drainage blanket installed to collect seepage through the embankment, and the pervious blankets at the abutment contacts to collect and remove leakage from the abutments, a system of horizontal drain holes has been installed in each abutment to collect and remove abutment leakage. At lower pools these drain holes are partially effective in intercepting the abutment leakage before it can enter the embankment and overload the drainage system incorporated into the embankment structure. At higher pools, however, the leakage exits uncontrolled on the abutment/embankment contact at higher elev's. Plates 71 through 81 show the flow from these drain holes and the corresponding pool level. The combination of grout curtain and abutment drainage has lowered the piezometric level in the abutments from 40 to 55 percent during high pool levels, as shown by piezometer water level plots in Plates 63 through 70.

59. Internal Drainage Blankets. The internal drainage of the embankment is accomplished by a chimney drain and horizontal drainage blanket. Abutment blankets of pervious material intercept drainage or leakage through the abutment before it can saturate the downstream random zone of the embankment. Because of the effectiveness of these internal drainage features the downstream random zone is well drained and complies with the design assumptions for the steady seepage case of stability analysis. Flow from the toe drain system is plotted on plate 74 with corresponding pool levels.

60. <u>Drain Holes</u>. Drain holes were installed in the abutments to collect and remove abutment leakage before it could saturate the embankment and to relieve pressure within the abutments. The location of the drain holes are shown on plate 43. Details of the installation are shown on plates 46 and 47. Water removed from the abutment through these drains is measured with flumes strategically located in the downstream toe area. Plots of flow and corresponding pool levels are shown in plates 71 through 81. The drains have been extremely helpful in lowering the piezometric surface in the abutments as shown by piezometer plots in plates 63 through 70; however, at higher pool levels the leakage exits uncontrolled on the abutment/embankment contact at higher elevations.

PART VIII - FOUNDATION AND EMBANKMENT SETTLEMENT

61. Foundation Overburden. In the streambed area the foundation overburden consisted primarily of alluvial sand and gravel deposits. Deep deposits of talus were found on each abutment. The talus was removed from the abutments to eliminate the possibility of differential settlement. The streambed alluvium was removed to primary formation in the cutoff trench, and to elevation 6050 upstream and 6045 downstream. Very little settlement of overburden material was expected, and most of it would occur during construction.

62. Foundation Bedrock. The abutment primary formations are dense and well-consolidated. Settlement of these formations under the embankment loading would be minor. Consolidation of the streambed primary formation would be expected to occur primarily in the clay and shale zones. The estimated 50-year settlement of the foundation bedrock under the maximum height of embankment was expected to be between 7 and 14 inches for after-construction settlement and 8 to 17 inches during construction. An estimated post-construction settlement of 6 inches was selected for determining camber for the embankment section.

63. Embankment. Consolidation tests indicated that the 50-year settlement after construction would be between 5 and 7 feet for the maximum embankment section and between 6 and 10 feet would occur during the 3 year construction period. Three and one-half (3.5) feet of camber was selected for embankment consolidation after construction.

64. Overbuild. Although the consolidation studies indicated that an overbuild of 4 feet would be required to compensate for anticipated 50-year settlement, the embankment was actually overbuilt only 2 feet between station 10+00A and 14+00A, with transitions of about 500 feet each way. The actual settlement is not precisely known; however, between 18 August 1970 and 30 May 1981 a maximum settlement of 0.417 feet has been observed.

PART IX - DEWATERING, DIVERSION, AND CLOSURE

65. Dewatering. A partial cutoff was installed through the streambed alluvium during construction of the upstream cofferdam to control seepage of river water into the excavation for the cutoff trench. This reduced the amount of water in the cutoff trench but pumping was required. Several small springs developed in the sandstone exposed during excavation. Grouting along the axis and in the vicinity of the individual springs sealed off most of the flow permitting placement of the fill in the dry.

66. Stage I Cofferdam Closure and Embankment Placement. During Stage I embankment construction the Rio Chama was diverted through the outlet works tunnel, which has an upstream invert elevation of 6060.0. The upstream cofferdam was specified to be constructed as a part of the waste fill section of the embankment and to remain in place. The contractor was permitted to make changes that would increase the width, height, section, or stone protection specified, except that a minimum 100 foot wide channel at elevation 6089 be maintained through the cofferdam. No requirement was specified as to quality or compaction of materials for cofferdam embankments or stone protection, except that all material for cofferdam construction, including rock for stone protection, would be obtained from the required excavation. Embankment height for Stage I construction, except for a minimum 100-foot wide channel at elevation 6089.0, was required to be a minimum of 6100 elevation before the spring rainy season. Excavation of the abutments was made to about elevation 6120 during Stage I construction. Plate 48 shows a plan view of the Stage I embankment. Plate 2 shows the minimum elevation for each stage of embankment.

67. Stage II Construction. Excavation of the abutments was performed from elevation 6120 to 6250 during Stage II embankment construction. The embankment was constructed to a minimum elevation of 6250 during this period.

68. Stage III Construction. The Stage III construction completed the embankment from from elevation 6250 to the crest. Phase III stripping of the abutments was completed in March 1962. All construction was completed by February 1963.

69. Diversion and Closure-General. Diversion and closure were effected without serious problems developing. The work was able to be performed in a relatively dry environment without serious losses due to overtopping or inundation.

X - INSTRUMENTATION

70. Physical Measurement Devices - General. Design memorandum No. 7, Embankment and Spillway, stated that no settlement plates or piezometers would be installed in the foundation or embankment, but that overall settlement would be checked by periodic surveys along the crest of the dam. However, a need for instrumentation to measure water levels and horizontal and vertical deflections of the embankment, abutments, tunnel, access shaft, intake structure, and flip bucket has subsequently been perceived. Consequently, piezometers have been installed in the embankment and abutments, surface settlement and horizontal movement points have been installed in the embankment, and settlement bolts and joint movement points have been installed in the outlet tunnel, access shaft, intake structure, and flip bucket. Parshall flumes were installed to permit the flow from the drain holes and toe drain system to be monitored quantitatively.

71. Foundation Piezometers. Eighteen piezometers have been installed in the abutments since 1966 to monitor the water levels and to permit an assessment of the effectiveness of the grouting and drainage provisions that have been constructed. Piezometers 10 through 14 were installed in the left abutment in 1966. In 1977, piezometers 15 through 18 were added to the left abutment and piezometers 19 through 27 were installed in the right abutment. In general, the abutment piezometers more clearly reflect changes in reservoir elevation than the embankment piezometers. All piezometers are open-tube type, and are located as shown on plate 49. Plots of piezometer water level and pool level are plotted on a time scale on plates 63 through 70. Piezometers are normally read on a monthly frequency, with weekly readings being taken during higher pool levels. The left

abutment piezometers, P-10, P-11, and P-12 are situated so as to give an indication of the amount of leakage through the left abutment, near the embankment contact. The plots of water level versus time for piezometers P-10, P-11, P-12, and the pool, shown on plates 63 and 64, show that water level in P-10, located approximately 125 feet upstream of the grout curtain, follows changes in pool elevation closely, with a slightly lower peak and a time lag of about one week. For the high pool condition represented by the 8 September 1980 reading P-10 is at 89.8 percent of the pool difference (assuming elevation 6050.0 as a bottom level), P-11 is 39.8 percent, and P-12 is 36.3 percent. For the condition represented by the readings taken 26 May 1981, P-10 is still at 89.8 percent of the pool difference, P-11 is 48.5 percent, and P-12 is 45.5 percent. The grout curtain appears to be responsible for a drop of from about 37 to about 47 percent of the total head difference. The effect of the grout curtain indicated by water levels in piezometers P-15 and P-14 is similar to that shown for P-10 and P-11, but the water level in piezometers P-15 and P-14 is slightly higher than in P-10 and P-11 for the same dates. Water level in piezometers P-16 and P-17 are lower than for P-15 and P-14 or P-10 and P-11. This appears to be indicating that no significant flow is coming around the end of the grout curtain, and a significant head drop is being caused by the grout curtain. The water level indicated by piezometer P-18 is fairly constant at about elevation 6100. This is about the elevation of the downstream slope of the embankment at the same distance downstream of the dam axis as P-18. There is a good probability that flow from the abutment could emerge at any point on the downstream embankment downstream of P-18, or below about elevation 6100. Seepage from the abutment upstream of this point would enter the pervious blanket and exit near the downstream toe. On the right abutment piezometers P-19, P-20, P20A, and P-21 monitor the water levels in

the abutment near the embankment contact. Plate 68 shows the plots of water level versus time for these piezometers. For the high water condition represented by the water levels recorded 8 September 1980, piezometer P-19, located 100 feet upstream of the grout curtain, indicates a water level that is about 70.9 percent of the total pool difference (using 6050 as a base elevation). This piezometer does not follow the pool fluctuactions nearly as closely as piezometer P-10, in the left abutment, which indicates that the right abutment is tighter than the left abutment, or is more effectively blanketed on the face by the waste berm. The head at the location of piezometer P-20 is about 61.6 percent, at P-20A about 54.2 percent, and at P-21 about 44.3 percent of the total head difference. This does not represent as much head drop at the grout curtain as in the left abutment. A head drop of about 5 percent is all that can be attributed to the grout curtain at this location. For the more normal pool condition represented by the water levels of 26 May 1981 the head at P-19 is about 78.3 percent, at P-20 about 70.9 percent, at P-20A about 64.4 percent, and at P-21 about 56.0 percent. The head drop at the grout curtain would be only about 3 percent of the total head difference. The other piezometers in the right abutment show water levels that are similiar to these, and generally verify the conclusions reached by analysis of piezometers P-19, P-20, P-20A, and P-21. As in the left abutment, abutment seepage downstream of P-21 could exit onto the downstream slope of the embankment at the contact. Seepage upstream of P-21 would enter the pervious blanket and exit at the downstream toe.

72. <u>Embankment Piezometers</u>. There are currently 16 piezometers in the embankment. Piezometers 1 through 9 were installed in 1966 and piezometers 28 through 35 were installed in 1977. Piezometer 33 has been destroyed and has not

been replaced. Piezometers further upstream show the most fluctuation with reservoir fluctuation. Piezometers 3, 4, 5, and 34 showed a significant decrease in water elevation upon completion of the toe drain in 1979. The location of these piezometers are shown on plate 49. Plots of piezometer and pool water levels versus time are shown on plates 56 through 62. These piezometers are scheduled to be read monthly except during high pool levels at which time they are read weekly.

73. <u>Surface Settlement and Horizontal Movement Points</u>. Fifteen surface settlement and horizontal movement points are located parallel to the centerline and 18 feet downstream from the embankment centerline. The initial readings were taken in August 1970. A second set of readings taken in June 1976 showed very little deviation. Since that time, the permanent reference monument was destroyed. A new monument has been installed and a new set of readings taken, which will now be the new reference for comparison to future readings. Data from the first two readings are shown in table 5, however the relatively small deviations shown indicate that settlement is less than anticipated and horizontal movement is negligible.

74. <u>Outlet Works Conduit Instrumentation</u>. There are three joint movement points, designated V-1, V-2, and V-3, in the access shaft located across horizontal joints. The measurements taken to date are shown on table 6. These measurements show a difference from 8 March 1977 to 21 January 1981 of only -.011 inches for point V-1, -.126 inches for point V-2, and +.041 inches for point V-3. These differences are too small to be of any concern. The intake structure has a settlement bolt, but only the initial reading has been taken since, on subsequent

surveys, the structure was submerged. The conduit downstream of the service gates has four joint movement points, designated JMP-1, JMP-2, JMP-3, and JMP-4, and 14 settlement bolts installed along the crown of the conduit. Table 7 shows the initial elevation of the settlement bolts and the elevation on January 1981. The difference is very small. A system for measuring cracks in the conduit was initiated in 1972. Measurements taken periodically since then have not shown any tendency for movement that should be cause for alarm. Crack photograph points have been installed to permit photographs to be made for comparison purposes.

XI - CONSTRUCTION NOTES

75. Embankment Construction History. Construction of the outlet works, including operations building and access road began in September 1956 and was completed in March 1959. Relocation of U.S. Highway 84, designed and constructed by the New Mexico Highway Department, was completed in July 1961. Construction of the embankment and spillway began in March 1959 and was completed in February 1963. Relocation of N.M. Highway 96 was completed in February 1963.

76. Changes in Design. During excavation for the intake structure a small slide developed on the north side of the planned structure. Approximately 2300 cubic yards of material were involved and the entire mass was removed during excavation. During construction of the embankment a large overrun in excavation unclassified occurred in stripping the abutments to suitable foundation material. Although the contract volume was for 1,750,000 cubic yards the final pay was to 3,412,000 cubic yards. The area and height of the waste fill berm were increased to provide a disposal area for a part of the overrun volume. The remainder was wasted in designated spoil areas.

77. Construction Modification.

a. Slope Stabilization. Because of continued sloughing and sliding of the slope above and adjacent to the intake structure contract 78-C-0044 was awarded for slope stabilization at this site. The excavation removed unstable material from between about elevation 6146 and 6340 over a length of about 1000 feet.

Plate 20 shows the location of the work, and plate 21 shows a plan and section of the repairs.

b. Abutment Drain Holes. The first series of drain holes was drilled in the left abutment in 1966. Ten holes were drilled to localize the seepage from a highly jointed white conglomerate sandstone. The holes were drilled 110 feet into the abutment beginning approximately 15 feet downstream of the abutment contact at elevation 6095. Twelve additional holes were drilled into the right abutment in 1977 at elevation 6096 starting approximately 20 feet from the abutment contact. Two holes were drilled in the same sandstone 800 feet downstream from the right abutment contact. During 1979, four holes were added to the left abutment and five holes drilled on the right abutment. In 1980, three holes were drilled on the left abutment and 4 holes were added to the right abutment. The location of the drain holes is shown on plate 43. Flow measurements have been taken weekly since 1974 from 5 Parshall flumes, located as shown also on plate 43. Plots of flow measurements and pool elevation with time are shown on plates 71 through 81. The plots of north abutment leakage on plates 71-74 show that in 1965 flow of about 2 c.f.s. occurred with a pool level of about 6180. After additional grouting was done in 1966 the flow rate for pool levels of 6160 to 6170 decreased to about 0.2 to 0.3 c.f.s. Another significant drop in the flow rate from the north abutment occurred after the supplemental grouting of the left abutment in 1980. The flow rate dropped to between 0.1 and 0.2 c.f.s. for pool levels between 6160 and 6180. The south abutment flow amounted to as much as 0.47 c.f.s. in 1977, with the pool at about elevation 6150. After supplemental grouting on the right abutment the flow rate declined from about 0.10 c.f.s. to about 0.15 c.f.s. for pool levels between 6160 and

6180. The flow from the north abutment drains correlates very well with water levels in piezometers P-10, P-11, and P-12 in the left abutment. The flow from the south abutment drains has more fluctuation than the piezometer water levels, but correlate with them in a general sort of way.

c. Toe Drain. A toe drain system was installed in 1979 at the location shown on plate 43. A flume for monitoring the flow from the toe drain system has been read on a weekly basis since 1979. Plots of the flow from the toe drain system with corresponding pool levels are shown on plate 74.

d. Initial Grouting and Supplemental Grouting. A single line grout curtain was installed along the centerline of the embankment from about sta. 3+00A to 21+00A as a part of the embankment construction contract. In 1966 supplemental grouting was performed to reduce seepage around the control shaft and in the left abutment. Sixteen holes were drilled and grouted around the control shaft to elevation 6115. Seepage into the control shaft was severely lessened and almost eliminated by this program. A 560 foot section of embankment foundation was re-grouted from 9+50A to 3+90A and a 500-foot length of grout curtain was installed in the left abutment. Between 1978 and 1980 two additional increments of supplemental grouting were completed. In the first contract 510 feet of the embankment foundation were re-grouted from station 14+70A to 19+80A, and a new 500-foot long grout curtain was installed in the right abutment. Under the second contract the grout curtains on each abutment were extended an additional 500 feet. The location of these grout curtains is shown on plate 43.

78. Construction Equipment. Stripping of the abutments was accomplished by drilling and blasting as required, loading the material with four and five cubic yard shovels, and hauling with end dump Euclid trucks. Excavation, transportation, and moisture control of the embankment borrow materials were performed in an unusual manner. Borrow excavation was accomplished with a wheel-type excavator having a capacity of 2,000 to 3,000 cubic yards per hour. The material was hauled in bottom-dump units to a loading hopper for a 4,300-foot belt conveyor system. A vibrating scalper removed oversize materials as the borrow material was fed onto the belt conveyor. The belt discharged the material into a receiving hopper located near the embankment area. Water was injected into the borrow material as it was discharged into bottom-dump units for the short haul to the embankment.

XII--OPERATIONAL NOTES

79. Embankment Performance History. The performance of the embankment since impoundment was initiated has generally been good. Instability of the abutment slope in the vicinity of the intake structure required the removal of talus material in 1978. The slope has been stable since this work was completed. The abutments leaked severely during the first raising of the pool in 1965. Supplemental grouting was performed in 1966, and again in 1978 and 1980 to reduce the leakage and uplift pressure in the abutments. Drain holes were installed in the abutments to collect and remove abutment leakage, and to keep it out of the embankment where it was overloading the toe drain system. A new toe drain system was constructed to collect and remove seepage and abutment leakage from the embankment toe area and divert it to the river channel. Instrumentation, consisting of 35 open-tube piezometers and 15 surface settlement and horizontal movement points, was installed in the embankment and abutments to monitor the embankment performance. Surveys of the settlement points indicate the embankment settlement is relatively minor, and horizontal movements are not significant. A Dam Safety Assurance Study revealed that, using the latest criteria, the PMF would be expected to overtop the embankment by about six feet. Plans are underway to increase the spillway width from 40 to 68 feet, and to increase the top of dam elevation from 6368.2 to 6383.0. Plates 50 through 55 show the proposed changes.

80. Reservoir Levels. Under the original plan of reservoir regulation no permanent storage of water was authorized. However, in 1967 a permanent pool of 2000 acre-feet was established. In December 1973 the sediment storage pool was

increased to 4000 acre feet. In 1974 a contract was made with the city of Albuquerque for storage of trans-mountain water in the remaining sediment storage space. The reservoir was drained in January 1976 to install bulkhead gates and remained empty through March. The pool was approved for 15,000 acre-feet of permanent storage in April 1976. In December 1981 storage of up to 200,000 acre-feet of storage was authorized. A graphic presentation of pool level is shown on plots of piezometer data on plates 56 through 70. The three highest reservoir elevations for this period were; 21 June 1973, 6219.93; 14 June 1980, 6219.63; and 28 June 1979, 6205.26. However, since these data were plotted, the reservoir experienced a new maximum pool of 6256.23 on 17 June 1985.

81. Seepage. Although no piezometers were installed initially, a total of 35 open-tube piezometers have been installed since construction was completed to monitor water levels within the embankment and abutments. The water levels indicated by these piezometers are shown on plates 56 through 70. The greatest response to reservoir fluctuation is seen in the piezometers located in the abutments. Measurements of leakage and seepage flow rates are shown on plates 71 through 81. Grouting has reduced the piezometric surface in the left abutment downstream of the grout curtain about 10 feet. Abutment drains have diverted leakage through the abutments away from the embankment toe and toe drain system for lower pool levels. For these pool levels leakage and seepage are controlled by the internal drainage features of the embankment and the horizontal drain holes in the abutments. However, at high pool levels abutment leakage can exit on the surface of the embankment, or into the pervious blanket, causing erosion or overloading the internal drainage system.

82. Inspections. Periodic inspections, in accordance with ER 1110-2-100, were performed on 28 October 1970, 22 June 1976 and 10 June 1981. Reports of these inspections are on file in the District Office and at the project. In addition to these inspections, Mr. Lewis C. Slack was contracted to inspect the embankment during periods of high reservoir levels. Inspections and reviews of instrumentation were performed weekly by Mr. Slack during these periods. The following table lists the dates during which inspections were made and reports submitted.

FIELD OBSERVATIONS, CONDITIONS AND PERFORMANCE EVALUATIONS

Year	Report No.	Date of Inspection	Pool Elevation
1979	1	27 April 1979	
		1 May 1979	
		8 May 1979	
		15 May 1979	6177
	2	Report No. 2 cannot be located.	
	3	5 June 1979	
		12 June 1979	6201.8
	4	19 June 1979	
		26 June 1979	6205.2
	5	3 July 1979	6203.1
		10 July 1979	
	6	17 July 1979	6199.4
1980	1	6 May 1980	6180.2
		13 May 1980	6192.2
	2	20 May 1980	
		28 May 1980	6207.65
	3	3 June 1980	
		10 June 1980	6218.2
	4	16 June 1980	6219.4
		23 June 1980	6216.4

FIELD OBSERVATIONS, CONDITIONS AND PERFORMANCE EVALUATIONS

Year	Report No.	Date of Inspection	Pool Elevation
	5	30 June 1980	6211.9
		7 July 1980	6206.0
	6	14 July 1980	6203.2
		21 July 1980	6203.3
	7	28 July 1980	6203.1
		4 August 1980	6203.0
1984	1	16 May 1984	6215
		24 May 1984	6225
		31 May 1984	6228
	2	8 June 1984	6226
		15 June 1984	6221
	3	22 June 1984	6218
		28 June 1984	6213
	4	6 July 1984	6209
		13 July 1983	6209
	5	20 July 1984	6209
		27 July 1984	6209
		3 August 1984	6209

83. Field Observations During Spring Runoff. Reports of field observations listed above were made by Mr. Lewis C. Slack to cover periods of high reservoir levels. The field inspections were performed weekly and included inspection of the embankment and abutments, evaluation of instrumentation readings, and recommendations for treatment of problems observed. In report number 1, dated 18 May 1979, Mr. Slack recommended that additional and deeper drain holes be installed in the white sandstone layer of both the right and left abutments downstream of the dam. As a result of these observations and recommendations the additional drain holes were installed later in 1979, and a record of visual

inspection of the pertinent project features and upstream and downstream areas was established. These field observations are included in the periodic inspection reports to make them a part of the permanent project records.

84. Parshall Flumes. Five Parshall flumes have been installed at the locations shown on plate 43 to measure flow from abutment drain holes, the toe drain system, and abutment leakage. The flow measured by these Parshall flumes is plotted on plates 71 through 81. The flows shown in these plots have been influenced by construction activity during installation of the toe drain system, the additional piezometers and drain holes, the supplemental grouting, and other work in the area. However, the flow can be seen to fluctuate with pool, and the effects of the supplemental grouting can be observed.

TABLE NO. 1
SUMMARY OF CLASSIFICATION TESTS
BORROW AREA B-1

HOLE NO.	DISTRICT LAB. NO.	LOCATION	DEPTH (FT)	MECHANICAL ANALYSIS GRAVEL %	SAND %	FINES %	D_{10} mm	ATTERBERG LIMITS LL %	PI %	SL %	FIELD MOIST %	CLASSIFICATION [illegible]	[illegible]	REMARKS FROM DRILLERS LOG
AB-83	46766	See Plate No. 1	0.0-3.5									Silty Clay	CL-ML	
AB-83	46767	for Location	3.5-8.0	0	33	67		20	13	6		Sandy Clay	CL	
AB-83	46768	of Auger Holes	8.0-9.5									Silty, Sandy Gravel	GM	Rock @ 9.5'
AB-84	46769		0.0-2.5								8.5	Silty Clay	CL	
AB-84	46770		2.5-4.5	2	23	75		33	13	6		Sandy Clay	CL	
AB-84	46771		4.5-7.0									Silty Clay	CL	
AB-84	46772		7.0-8.0								3.9	Silty Clay	CL	
AB-84	46773		8.0-15.0	0	5	95		40	17	11		Lean Clay	CL	
AB-84	46774		15.0-16.0									Sandy Silt	ML	Sand Pocket @ 16', hole caved
AB-85	46775		0.0-3.0	10	43	47		32	13	8		Clayey Sand	SC	
AB-85	46776		3.0-6.0									Silty Clay	CL-ML	
AB-85	46777		6.0-10.0									Silty Clay	CL-ML	
AB-85	46778		10.0-13.0	4	20	76		30	11	10		Sandy Clay	CL	
AB-85	46779		13.0-16.0									Silty Clay	CL	Rock @ 16'
AB-86	46780		0.0-1.0									Silty Clay	CL	
AB-86	46781		1.0-3.5									Silty Clay	CL	
AB-86	46782		3.5-5.5	3	25	72		33	14	8	9.0	Sandy Clay	CL	
AB-86	46783		5.5-6.0									Lean Clay	CL	
AB-86	46784		6.0-7.0									Silty Clay	CL	
AB-86	46785		7.0-9.0									Silty Clay	CL	
AB-86	46786		9.0-10.0	2	29	69					9.8	Clayey Silt	ML-CL	
AB-86	46787		10.0-13.0	5	44	51					8.9	Silty Clay	CL	
AB-86	46788		@ 13.0									Silty Clay	CL	Rock @ 13'
AB-87	46789		0.0-2.5									Silty Clay	CL	
AB-87	46790		2.5-3.0	2	20	78		45	24	9		Sandy Clay	CL	
AB-87	46791		3.0-3.8	0	12	88		51	31	13		Clay	CH	
AB-87	46792		3.8-7.0									Silty Clay	CL	
AB-87	46793		7.0-9.5									Silty Clay	CL	Hole caved @ 9'
AB-88	46794		0.0-2.0	10	39	51		31	12	6		Sandy Clay	CL	
AB-88	46795		2.0-5.5									Sandy Clay	CL	Rock @ 5.5', hole caved
AB-89	48979		0.0-2.0	62	20	18						Sandy Silt	ML	
AB-89	48980		2.0-4.0									Sandy Clay	CL	Rock @ 4', hole caved
AB-90	48981		0.0-2.5									Sandy Silt	ML	
AB-90	48982		2.5-3.0	0	22	78		26	9	8		Sandy Clay	CL	
AB-90	48983		3.0-5.0									Sandy Gravel	GP	Rock @ 5.0', hole caved
AB-91	48984		0.0-2.0									Silty Clay	CL	
AB-91	48985		2.0-3.0	1	27	72		33	15	10		Sandy Clay	CL	
AB-91	48986		3.0-6.5									Sandy Silt	ML	
AB-91	48987		6.5-10.0	45	46	9						Silty Gravelly Sand	SP-SM	Sand & Gravel @ 10', hole caved
AB-91	48988		10.0-11.0									Silty Sand	SM	
AB-92	48990		0.0-1.0									Sandy Silt	ML	
AB-92	48991		1.0-5.0									Silty Gravel	GM	Sand & Gravel @ 5', hole caved
AB-93	48992		0.0-1.0	14	46	40		21	4	4		Silty Sand	SM-SC	
AB-93	48993		1.0-5.0									Silty Gravel	GM	Rock @ 5', hole caved
AB-94	48994		0.0-1.5	3	47	50		23	4	3		Silty Sand	SM-SC	
AB-94	48995		1.5-4.5	3	42	55		33	15	6		Sandy Clay	CL	
AB-94	48996		4.5-6.0									Silty Gravel	GM	Rock @ 6', hole caved
AB-95	48997		0.0-1.0									Silty Clay	CL-ML	
AB-95	48998		1.0-4.0	61	24	15						Silty Gravel	GM	Rock @ 1.5', able to drill to 4'
AB-96	48999		0.0-1.0	10	32	58		37	16	9		Sandy Clay	CL	
AB-96	49000		1.0-4.0									Sandy Silt	ML	
AB-96	49001		4.0-7.0									Silty Gravel	GM	
AB-96	49002		7.0-9.5	12	31	57		36	15	13		Sandy Clay	CL	
AB-96	49003		9.5-10.0									Sandy Clay	CL-ML	Rock @ 10'
AB-97	49004		0.0-1.0	12	42	46		23	7	6		Clayey Sand	SC-SM	
AB-97	49005		1.0-4.0									Silty Gravel	GM	Rock @ 4', hole caved
AB-113	49062		0.0-7.0									Silty Clay	CL	
AB-113	49063		7.0-10.5									Silty Sand	ML-CL	
AB-113	49064		10.5-13.0	1	48	51		22	4	4		Sandy Silt	ML-CL	Sand & Gravel 11', hole caved
AB-114	49065		0.0-1.5									Silty Gravel	GM	
AB-114	49066		1.5-11.0	4	47	49		21	5	7		Clayey Sand	SC-SM	
AB-114	49067		11.0-17.5									Sandy Silt	ML	
AB-114	49068		17.5-20.0	0	30	70		25	4	3		Sandy Silt	ML-CL	
AB-115	49069		0.0-3.0									Sandy Silt	ML-CL	
AB-115	49070		3.0-7.0									Clayey Silt	ML-CL	
AB-115	49071		7.0-8.0	3	29	68						Sandy Silt	ML-CL	Sand & Gravel @ 8', hole caved
AB-116	49072		0.0-1.0									Silty Gravel	GM	
AB-116	49073		1.0-12.0									Clayey Sand	SC-SM	
AB-116	49074		12.0-20.0	2	50	48		26	7	6		Sandy Clay	CL	
AB-117	49075		0.0-5.0	16	47	37		20	3	3		Gravelly Silty Sand	SM	
AB-117	49076		5.0-7.0									Sandy Clay	CL	
AB-117	49077		7.0-9.0	1	31	68		30	11	8		Sandy Clay	CL	
AB-117	49078		9.0-14.0									Sandy Clay	CL	
AB-117	49079		14.0-16.0	2	34	64		20	6	6		Sandy Clay	CL-ML	Rock @ 16', appeared solid
AB-118	49080		0.0-8.0	6	50	44		22	4	4		Silty Sand	SM-SC	
AB-118	49081		8.0-20.0									Clayey Sand	SC	

TABLE NO. 1 (CONT'D)
SUMMARY OF CLASSIFICATION TESTS
BORROW AREA B-1

HOLE NO.	DISTRICT LAB. NO.	LOCATION	DEPTH (FT)	MECHANICAL ANALYSIS GRAVEL %	SAND	FINES	D_{10} mm	ATTERBERG LIMITS LL %	PI %	LS %	FIELD MOIST %	CLASSIFICATION ADJ	L/R	REMARKS FROM DRILLER'S LOG
AB-119	49082	See Plate No. 1	0.0-7.0	14	37	49		28	10	8		Clayey Sand	SC	
AB-119	49083	for Location	7.0-11.0									Sandy Clay	CL	Rock @ 11'
AB-120	49084	of Auger Holes	0.0-5.0									Sandy Clay	CL	
AB-120	49085		5.0-13.0	5	46	49		21	1	0		Sandy Silt	ML	
AB-120	49086		13.0-15.5									Sandy Silt	ML	Rock @ 15.5'
AB-121	49087		0.0-4.0	25	46	29		22	5	5		Gravelly Silty Sand	SM	
AB-121	49088		4.0-8.0	1	22	77		27	10	7		Sandy Clay	CL	
AB-121	49089		8.0-12.0									Sandy Silt	ML	
AB-121	49090		12.0-15.0									Sandy Silt	ML	
AB-121	49091		15.0-18.5	1	37	62		26	7	5		Sandy Clay	CL-ML	Rock @ 18.5'
AB-122	49092		0.0-2.0									Clayey Gravel	GC	
AB-122	49093		2.0-4.0									Sandy Clay	CL-ML	
AB-122	49094		4.0-9.5	8	70	22		21	8	4		Clayey Sand	SC	
AB-122	49095		9.5-20.0									Silty Gravel	GM	
AB-123	49096		0.0-4.0	1	42	57		24	6	5		Sandy Clay	CL-ML	
AB-123	49097		4.0-6.0									Sandy Clay	CL-ML	
AB-123	49098		6.0-9.0	0	55	45		20	2	1		Silty Sand	SM	Rock @ 9'
AB-124	49099		0.0-1.0	32	55	13	.015	17	NP	1		Silty Gravelly Sand	SM	
AB-124	49100		1.0-4.5									Sandy Silt	ML	
AB-124	49101		4.5-18.0	0	49	51		30	13	6		Sandy Clay	CL	
AB-124	49102		18.0-20.0	0	67	33		23	2	1		Silty Sand	SM	
AB-126	49107		0.0-3.0									Gravelly Silty Sand	SM	
AB-126	49108		3.0-6.0	1	57	42		22	5	4		Sandy Clay	CL-ML	
AB-126	49109		6.0-18.0									Clayey Silt	ML-CL	
AB-126	49110		18.0-20.0	0	61	39		23	4	5		Sandy Silty	ML-CL	
AB-127	49111		0.0-1.0									Sandy Clay	CL	
AB-127	49112		1.0-6.0	0	42	58		25	10	11		Sandy Clay	CL	
AB-127	49113		6.0-15.0	0	30	70		45	24	13		Sandy Clay	CL	Rock @ 15'
AB-128	49620		0.0-5.0	0	33	67		35	13	10		Sandy Clay	CL	
AB-128	49621		5.0-8.0									Sandy Clay	CL	
AB-128	49622		8.0-12.0	1	54	45		27	9	6		Clayey Sand	SC	
AB-128	49623		12.0-14.0	0	52	48		27	12	4		Clayey Sand	SC	
AB-128	49624		14.0-16.0									Lean Clay	CL	
AB-128	49625		16.0-17.0									Silty Clay	CL	Rock @ 17'
AB-129	49626		0.0-5.0	0	55	45		26	8	6		Clayey Sand	SC	
AB-129	49627		5.0-7.0	0	40	60		34	20	9		Sandy Clay	CL	
AB-129	49628		7.0-9.0									Sandy Silt	ML	
AB-129	49629		9.0-12.0	0	24	76		33	12	12		Sandy Clay	CL	Rock @ 12'
AB-130	49630		0.0-5.0									Silty Clay	CL	
AB-130	49631		5.0-8.0	0	34	66		38	18	12		Sandy Clay	CL	
AB-130	49632		8.0-10.0									Sandy Clay	CL	Rock @ 10'
AB-131	49633		0.0-3.0	0	22	78		31	9	7		Sandy Clay	CL-ML	
AB-131	49634		3.0-5.0	44	24	32		28	11	7		Clayey Sandy Gravel	GC	Large Rock @ 5'
AB-132	49635		0.0-4.0									Clayey Sandy Gravel	GC	Rocks on surface, unable to drill deeper
AB-133	49636		0.0-5.0									Sandy Clay	CL-ML	
AB-133	49637		5.0-6.0									Sandy Clay	CL-ML	Rock @ 6'
AB-134	49638		0.0-4.0									Sandy Clay	CL	
AB-134	49639		4.0-5.0									Silty Sandy Gravel	GM	Rock @ 4'
AB-136	49640		0.0-1.0	0	36	64		27	7	6		Sandy Clay	CL-ML	
AB-136	49641		1.0-3.0									Silty Clay	CL-ML	Rock @ 3'
AB-137	49642		0.0-3.0									Silty Clay	CL-ML	
AB-137	49643		3.0-4.0	35	30	35		27	10	7		Clayey Sandy Gravel	GC	Boulder @ 3'
AB-138	49644		0.0-4.0									Sandy Clay	CL	
AB-138	49645		4.0-6.0	0	19	81		31	12	12		Sandy Clay	CL	Rock @ 6'
AB-139	49646		0.0-5.0	0	30	70		35	14	8		Sandy Clay	CL	
AB-139	49647		5.0-6.0									Silty Clay	CL-ML	
AB-139	49648		6.0-7.0									Gravelly Sandy Silt	GM	Large Rock @ 7'
AB-140	49649		0.0-5.0	0	34	66		37	14	8	13.8	Sandy Clay	CL	
AB-140	49650		5.0-8.0									Sandy Silt	ML-CL	
AB-140	49651		8.0-11.0								10.4	Sandy Clay	CL-ML	Rock @ 11'
AB-141	49652		0.0-5.0	0	31	69		36	13	9		Sandy Clay	CL	
AB-141	49653		5.0-7.0									Sandy Clay	CL	
AB-141	49654		7.0-10.0									Sandy Silt	ML	
AB-141	49655		10.0-11.0									Sandy Silt	ML	
AB-141	49656		11.0-14.0	4	27	69		40	19	9		Sandy Clay	CL	
AB-141	49657		14.0-18.0	0	17	83		38	9	6		Silty Clay	CL	Rock @ 18'
AB-142	49658		0.0-4.0									Sandy Clay	CL-ML	
AB-142	49659		4.0-5.0	1	78	21		—	NP	—		Silty Sand	SM	Rock @ 5'
AB-143	49660		0.0-4.0									Sandy Silt	ML	
AB-143	49661		4.0-8.0	1	43	56		31	9	6		Sandy Clay	CL-ML	
AB-143	49662		8.0-9.0	0	37	63		36	11	8		Sandy Clay	CL	
AB-143	49663		9.0-11.0									Silty Clay	CL	
AB-143	49664		11.0-13.0									Silty Clay	CL	Rock @ 13'

TABLE NO. 1 (CONT'D)
SUMMARY OF CLASSIFICATION TESTS
BORROW AREA B-1

HOLE NO.	DISTRICT LAB. NO.	LOCATION	DEPTH (FT)	MECHANICAL ANALYSIS GRAVEL %	SAND %	FINES %	D_{10} mm	ATTERBERG LIMITS LL %	PI %	LS %	FIELD MOIST %	CLASSIFICATION ADJ	LTR	REMARKS FROM DRILLERS LOG
AB-144	49665	See Plate No. 1	0.0-5.0	1	37	62		26	11	5		Sandy Clay	CL	
AB-144	49666	for Location	5.0-6.0	0	27	73		33	16	9		Sandy Clay	CL	
AB-144	49667	of Auger Holes	6.0-7.0									Silty Sand	SM	Rock @ 7'
AB-145	49668		0.0-4.0									Silty Sandy Gravel	GM	
AB-145	49669		4.0-6.0									Silty Sandy Gravel	GM	Large Rock @ 4.0', hole caved
AB-146	49670		0.0-4.0	0	31	69		37	16	12		Sandy Clay	CL	
AB-146	49671		4.0-7.0									Silty Clay	ML	
AB-146	49672		7.0-8.0									Silty Sandy Gravel	GM	Rock @ 8', hole caved
AB-148	49673		0.0-1.0	2	38	60		29	11	10		Sandy Clay	CL	
AB-148	49674		1.0-4.0	59	27	14		28	9	8		Clayey Sandy Gravel	GC	Rock @ 1', unable to drill deeper than 4'
AB-149	49675		0.0-4.0									Sandy Clay	CL	
AB-149	49676		4.0-5.0	34	34	32		26	10	6		Clayey Sandy Gravel	GC	Rock @ 4', hole caved
AB-150	49677		0.0-4.0	0	29	71		30	13	8		Sandy Clay	CL	
AB-150	49678		4.0-6.0									Sandy Clay	CL	
AB-150	49679		6.0-8.0	0	17	83		41	18	9		Sandy Clay	CL	Rock @ 8'
AB-151	49680		0.0-3.0									Sandy Clay	CL-ML	
AB-151	49681		3.0-5.0	0	38	62		30	12	6		Sandy Clay	CL	
AB-151	49682		5.0-7.0	0	44	56		30	13	7		Sandy Clay	CL	
AB-151	49683		7.0-10.0									Sandy Clay	CL	
AB-151	49684		10.0-11.0									Sandy Silt	ML-CL	Rock @ 11'
AB-152	49685		0.0-4.0									Sandy Clay	CL	
AB-152	49686		4.0-6.0	0	64	36		23	7	6	5.8	Clayey Sand	SC-SM	
AB-152	49687		6.0-9.0									Sandy Clay	CL-ML	
AB-152	49688		9.0-11.0								6.3	Silty Sand	SM	
AB-152	49689		11.0-13.0	0	65	35		24	7	6		Clayey Sand	SC-SM	
AB-152	49690		13.0-15.0	0	47	53		25	8	6	7.3	Sandy Clay	CL-ML	
AB-152	49691		15.0-17.0									Sandy Clay	CL	
AB-152	49692		17.0-19.0								5.4	Sandy Clay	CL-ML	Rock @ 19'
AB-153	49693		0.0-3.0	2	71	27		20	2	2		Silty Sand	SM	
AB-153	49694		3.0-6.0	2	73	25		21	4	0		Silty Sand	SM-SC	
AB-153	49695		6.0-9.0									Sandy Silt	ML	
AB-153	49696		9.0-11.0									Lean Clay	CL	
AB-153	49697		11.0-16.0									Silty Sand	SM	Rock @ 16'
AB-154	49698		0.0-4.0	0	41	59		40	21	11		Sandy Clay	CL	
AB-154	49699		4.0-6.0									Sandy Silt	ML	
AB-154	49700		6.0-7.0	0	13	87		40	18	13		Clay	CL	
AB-154	49701		7.0-9.0									Sandy Clay	CL	
AB-154	49702		9.0-11.0	0	21	79		47	22	13		Sandy Clay	CL	
AB-154	49703		11.0-13.0	0	65	35		21	8	4		Clayey Sand	SC	Rock @ 13'
AB-155	49704		0.0-3.0									Sandy Clay	CL	
AB-155	49705		3.0-5.0									Sandy Clay	CL	
AB-155	49706		5.0-7.0	0	38	62		27	10	7		Sandy Clay	CL	
AB-155	49707		7.0-9.0									Sandy Silt	ML	
AB-155	49708		9.0-13.0	0	69	31		22	4	2		Silty Sand	SM-SC	
AB-155	49709		13.0-16.0	0	20	80		50	28	7		Clay	CH	
AB-155	49710		16.0-17.0									Sandy Clay	CL-ML	Rock @ 17'
AB-156	49711		0.0-3.0	0	42	58		27	9	9		Sandy Clay	CL	
AB-156	49712		3.0-5.0	0	46	54		27	12	6		Sandy Clay	CL	
AB-156	49713		5.0-7.0									Silty Sand	SM-SC	
AB-156	49714		7.0-10.0									Sandy Clay	CL	
AB-156	49715		10.0-12.0	21	57	22		27	11	8		Clayey Sand	SC	Rock @ 12'
AB-157	49716		0.0-3.0									Sandy Clay	CL	
AB-157	49717		3.0-6.0									Sandy Clay	CL-ML	Rock @ 6'
AB-158	49718		0.0-3.0	1	51	48		34	12	10		Clayey Sand	SC	
AB-158	49719		3.0-5.0									Sandy Clay	CL	Rock @ 5'
AB-159	49720		0.0-1.0	18	31	51		31	9	8		Sandy Gravelly Silt	ML	
AB-159	49721		1.0-5.0	52	33	15		25	7	4		Clayey Sandy Gravel	GC	Rock @ 5'
AB-160	49722		0.0-1.0									Sandy Clay	CL-ML	
AB-160	49723		1.0-4.0									Lean Clay	CL	Rock @ 4'
AB-161	49724		0.0-3.0	3	37	60		30	8	5		Sandy Clay	CL	
AB-161	49725		3.0-5.0	0	22	78		40	16	16		Sandy Clay	CL	
AB-161	49726		5.0-6.0									Silty Sand	SM-SC	Rock @ 6', able to drill to 10', hole caved
AB-161	49727		6.0-10.0	37	28	35		26	7	6		Clayey Sandy Gravel	GC-GM	
AB-162	49728		0.0-3.0									Sandy Clay	CL-ML	
AB-162	49729		3.0-4.0									Silty Clay	ML-CL	
AB-162	49730		4.0-5.0	45	23	32		33	11	9		Clayey Sandy Gravel	GC	Rock @ 4', hole caved
AB-163	49731		0.0-1.0	0	48	52		25	9	7		Sandy Clay	CL	
AB-163	49732		1.0-4.0									Sandy Clay	CL-ML	
AB-163	49733		4.0-6.0	0	43	57		38	17	11		Sandy Clay	CL	
AB-163	49734		6.0-8.0	0	8	92		56	32	18		Clay	CH	
AB-163	49735		8.0-9.0									Sandy Clay	CL-ML	Rock @ 9'
AB-164	49736		0.0-1.0	0	56	44						Clayey Sand	SC	
AB-164	49737		1.0-4.0									Sandy Clay	CL	

TABLE NO. 1 (CONT'D)
SUMMARY OF CLASSIFICATION TESTS
BORROW AREA B-1

HOLE NO.	DISTRICT LAB. NO.	LOCATION	DEPTH (FT)	MECHANICAL ANALYSIS GRAVEL %	SAND %	FINES %	D_{10} mm	ATTERBERG LIMITS LL %	PI %	SL %	FIELD MOIST %	CLASSIFICATION	LTR	REMARKS FROM DRILLERS LOG
AH-164	49738	See Plate No. 1 for Location of Auger Holes	4.0-7.0	0	35	65		32	14	8		Sandy Clay	CL	
AH-164	49739		7.0-12.0									Clayey Sand	SC	Rock @ 12'
AH-165	49740		0.0-1.0	0	42	58		30	13	5		Sandy Clay	CL	
AH-165	49741		1.0-6.0									Silty Sandy Gravel	GM	
AH-165	49742		6.0-8.0									Sandy Clay	CL-ML	
AH-165	49743		8.0-9.0									Sandy Silt	ML	
AH-165	49744		9.0-12.0	0	53	47		23	10	6		Clayey Sand	SC	
AH-165	49745		12.0-15.0									Sandy Silt	ML	
AH-165	49746		15.0-17.0	0	26	74		44	23	13		Sandy Clay	CL	Rock @ 17'
AH-166	49747		0.0-1.0									Sandy Clay	CL-ML	
AH-166	49748		1.0-4.0	0	39	61		32	13	10		Sandy Clay	CL	
AH-166	49749		4.0-7.0								13.8	Sandy Clay	CL-ML	
AH-166	49750		7.0-9.0	0	19	81		38	20	12	9.2	Sandy Clay	CL	
AH-166	49751		9.0-12.0	0	38	62		27	10	5	7.1	Sandy Clay	CL	Rock @ 12'
AH-167	49752		0.0-1.0									Sandy Clay	CL	
AH-167	49753		1.0-5.0									Sandy Clay	CL	
AH-167	49754		5.0-6.0									Silty Sand	SM	Rock @ 6'
AH-168	49755		0.0-1.0	0	47	53		21	5	5		Sandy Silt	ML-CL	
AH-168	49756		1.0-5.0									Sandy Clay	CL	
AH-168	49757		5.0-7.0									Sandy Clay	CL-ML	
AH-168	49758		7.0-9.0	0	25	75		45	23	14		Sandy Clay	CL	Rock @ 9'
AH-169	49759		0.0-1.0									Sandy Clay	CL-ML	
AH-169	49760		1.0-3.0									Sandy Clay	CL-ML	Rock @ 3'
AH-170	49761		0.0-1.0	0	36	64		21	6	5		Sandy Clay	CL-ML	
AH-170	49762		1.0-5.0									Sandy Clay	CL	Rock @ 5'
AH-172	49763		0.0-1.0	1	60	39		19	3	2		Silty Sand	SM	
AH-172	49764		1.0-3.0									Sandy Clay	CL	Rock @ 3'
AH-173	49765		0.0-1.0					25	6	6		Sandy Clay	CL-ML	
AH-173	49766		1.0-5.0	0	31	69		37	17	10		Sandy Clay	CL	
AH-173	49767		5.0-6.0	0	26	74		35	16	9		Sandy Clay	CL	Rock @ 6'
AH-174	49768		0.0-5.0									Sandy Clay	CL	
AH-174	49769		5.0-6.0	1	57	42						Silty Sand	SM	
AH-174	49770		6.0-9.0									Sandy Clay	CL-ML	
AH-174	49771		9.0-10.0	3	80	17		25	9	7		Clayey Sand	SC	
AH-174	49772		10.0-12.0									Sandy Silt	ML-CL	
AH-174	49773		12.0-16.0					29	11	10		Sandy Clay	CL	
AH-174	49774		16.0-18.0	0	22	78		30	8	6		Sandy Clay	CL-ML	Rock @ 18'
AH-175	49775		0.0-1.0									Sandy Clay	CL	
AH-175	49776		1.0-4.0									Sandy Clay	CL	
AH-175	49777		4.0-6.0	0	31	69		32	12	9		Sandy Clay	CL	
AH-175	49778		6.0-9.0									Sandy Clay	CL	
AH-175	49779		9.0-10.0	0	28	72		38	18	9		Sandy Clay	CL	Rock @ 10'
AH-176	49780		0.0-1.0	4	56	40		24	4	3		Silty Sand	SM-SC	
AH-176	49781		.0-5.0	1	54	45		22	8	5		Clayey Sand	SC	
AH-176	49782		.0-7.0								7.3	Sandy Silt	ML-CL	
AH-176	49783		7.0-9.0									Sandy Silt	ML	
AH-176	49784		9.0-14.0	1	77	22		18	1	2	5.4	Silty Sand	SM	
AH-176	49785		14.0-16.0									Sandy Clay	CL-ML	
AH-176	49786		16.0-18.0					24	6	3	6.9	Clayey Sand	SC	
AH-176	49787		18.0-20.0	0	40	60		28	9	6	10.9	Sandy Clay	CL	
AH-177	49788		0.0-1.0	1	63	37		20	5	3		Silty Sand	SM-SC	
AH-177	49789		1.0-5.0									Sandy Clay	CL-ML	
AH-177	49790		5.0-7.0	7	36	57		35	13	10		Sandy Clay	CL	Fine sand @ 7'
AH-177	49791		7.0-11.0	2	69	29		20	1	2		Silty Sand	SM	Coarse Sand & Gravel @ 11'
AH-177	49792		11.0-12.0	22	65	13		18	3	2		Gravelly Silty Sand	SM	Rock @ 12'
AH-178	49793		0.0-1.0									Silty Gravelly Sand	SM	
AH-178	49794		1.0-5.0									Silty Clay	CL	
AH-178	49795		5.0-7.0	10	43	47		28	10	7		Clayey Sand	SC	
AH-178	49796		7.0-9.0									Sandy Clay	CL-ML	
AH-178	49797		9.0-12.0									Sandy Clay	CL	Rock @ 12'
AH-179	49798		0.0-1.0	5	47	48		28	12	8		Clayey Sand	SC	
AH-179	49799		1.0-5.0									Silty Sand	SM-SC	
AH-179	49800		5.0-7.0									Silty Clay	CL	
AH-179	49801		7.0-9.0	3	74	23		21	6	5		Clayey Sand	SC-SM	
AH-179	49802		9.0-13.0									Sandy Clay	CL-ML	
AH-179	49803		13.0-16.0									Sandy Clay	CL-ML	
AH-179	49804		16.0-17.0									Gravelly Silty Sand	SM	
AH-179	49805		17.0-20.0	5	76	19		21	2	1		Silty Sand	SM	
AH-180	49806		0.0-1.0									Silty Clay	CL	
AH-180	49807		1.0-6.0									Sandy Clay	CL-ML	Rock from 0 to 8', unable to drill through
AH-180	49808		6.0-8.0	4	50	46		25	10	[illegible]		Clayey Sand	SC	
AH-181	49809		0.0-5.0									Lean Clay	CL	
AH-181	49810		5.0-10.0	1	31	68		23	7	6		Sandy Clay	CL-ML	
AH-181	49811		10.0-12.0									Sandy Clay	CL	Rock @ 12'
AH-182	49812		0.0-1.0	5	33	62		25	6	4		Sandy Clay	CL-ML	
AH-182	49813		1.0-5.0									Silty Clay	CL	
AH-182	49814		5.0-6.0									Silty Clay	CL-ML	Rock @ 6'

TABLE NO. 1 (CONT'D)
SUMMARY OF CLASSIFICATION TESTS
BORROW AREA B-1

HOLE NO.	DISTRICT LAB. NO.	LOCATION	DEPTH (FT)	MECHANICAL ANALYSIS GRAVEL %	SAND %	FINES %	D_{10} mm	ATTERBERG LIMITS LL %	PI %	LS %	FIELD MOIST %	CLASSIFICATION [illegible]	LAB	REMARKS FROM DRILLERS LOG
AH-183	49815	See Plate No. 1	0.0-1.0	0	45	55		24	6	6		Sandy Clay	CL-ML	
AH-183	49816	for Location	1.0-4.0									Sandy Clay	CL	
AH-183	49817	of Auger Holes	4.0-6.0									Sandy Clay	CL-ML	
AH-183	49818		6.0-8.0	2	51	47		24	9	6		Clayey Sand	SC	
AH-183	49819		8.0-16.0	0	43	57		26	11	5		Sandy Clay	CL	
AH-183	49820		16.0-18.0									Sandy Clay	CL-ML	Rock @ 18'
AH-184	49821		0.0-1.0	3	58	39		17	3	2		Silty Sand	SM	
AH-184	49822		1.0-5.0									Clayey Silt	ML-CL	
AH-184	49823		5.0-10.0									Silty Clay	CL	
AH-184	49824		10.0-15.0									Sandy Clay	CL-ML	
AH-184	49825		15.0-20.0	0	43	57		31	14	6		Sandy Clay	CL	
AH-185	49826		0.0-2.0									Sandy Clay	CL	
AH-185	49827		2.0-5.0									Sandy Clay	CL	
AH-185	49828		5.0-7.0	0	27	63		30	11	6		Sandy Clay	CL	
AH-185	49829		7.0-14.0									Silty Sand	SM	
AH-185	49830		14.0-20.0	0	32	68		43	22	14		Sandy Clay	CL	
AH-186	49831		0.0-3.0									Sandy Clay	CL-ML	
AH-186	49832		3.0-6.0									Sandy Clay	CL	
AH-186	49833		6.0-12.0									Sandy Clay	CL	
AH-186	49834		12.0-18.0	9	33	58		31	14	9		Sandy Clay	CL	
AH-186	49835		18.0-20.0									Sandy Silt	ML-CL	
AH-187	49836		0.0-5.0	2	21	77		31	9	8		Sandy Clay	CL	
AH-187	49837		5.0-6.0									Silty Clay	CL	Rock @ 6'
AH-188	49838		0.0-4.0									Silty Clay	CL	
AH-188	49839		4.0-9.0									Silty Clay	CL	
AH-188	49840		9.0-11.0	2	68	30		22	7	4		Clayey Sand	SC-SM	
AH-188	49841		11.0-14.0									Sandy Clay	CL-ML	
AH-188	49842		14.0-18.0	0	42	58		24	8	4		Sandy Clay	CL	
AH-189	49843		0.0-5.0									Sandy Clay	CL	
AH-189	49844		5.0-11.0	0	22	78		29	13	8		Sandy Clay	CL	
AH-189	49845		11.0-13.0									Sandy Silt	ML	
AH-189	49846		13.0-18.0									Silty Clay	CL-ML	Hole caved @ 18'
AH-190	49847		0.0-1.0									Silty Clay	CL-ML	
AH-190	49848		1.0-5.0									Sandy Clay	CL-ML	
AH-190	49849		5.0-8.0									Sandy Silt	ML	
AH-190	49850		8.0-10.0	0	35	65						Sandy Clay	CL-ML	
AH-190	49851		10.0-13.0									Sandy Silt	ML	
AH-190	49852		13.0-15.0	0	45	55		27	13	6		Sandy Clay	CL	
AH-190	49853		15.0-20.0									Sandy Clay	CL-ML	
AH-191	49854		0.0-1.0									Sandy Clay	CL	
AH-191	49855		1.0-5.0	0	16	84		36	16	12		Sandy Clay	CL	
AH-191	49856		5.0-6.0									Sandy Clay	CL	
AH-191	49857		6.0-7.0									Sandy Clay	CL-ML	Rock @ 7'
AH-192	49858		0.0-5.0	0	35	65		28	10	7		Sandy Clay	CL	
AH-192	49859		5.0-10.0									Sandy Clay	CL	
AH-192	49860		10.0-14.0									Sandy Clay	CL-ML	
AH-192	49861		14.0-16.0	0	18	82		29	11	11		Sandy Clay	CL	Rock @ 16'
AH-193	49862		0.0-5.0									Silty Clay	CL	
AH-193	49863		5.0-7.0	0	23	77		30	14	7		Sandy Clay	CL	Rock @ 7'
AH-194	S-20716		0.0-1.0	6	48	46		22	7	5		Clayey Sand	SC-SM	
AH-194	S-20717		1.0-5.0	28	56	16		18	1	1		Silty Gravelly Sand	SM	Hole caved
AH-195	S-20718		0.0-1.0	85	8	7		24	9	6		Gravel	GP-GC	
AH-196	S-20719		0.0-5.0	4	39	57		22	7	4	6.2	Sandy Clay	CL-ML	
AH-196	S-20720		5.0-10.0	3	19	78		30	14	9	6.7	Sandy Clay	CL	
AH-196	S-20721		10.0-15.0	1	16	83		33	16	10	6.5	Sandy Clay	CL	Large rock @ 15'
AH-197	S-20722		0.0-5.0									Sandy Clay	CL	
AH-197	S-20723		5.0-10.0									Clayey Sand	SC	
AH-197	S-20724		10.0-13.0									Clayey Gravelly Sand	SC	Hole caved
AH-198	S-20725		0.0-5.0									Sandy Clay	CL	
AH-198	S-20726		5.0-7.0	10	49	41		22	6	5		Clayey Sand	SC-SM	Sand & Gravel @ 7', hole caved
AH-199	S-20727		0.0-5.0									Sandy Clay	CL	
AH-199	S-20728		5.0-9.0									Sandy Clay	CL	Shale @ 9'
AH-200	S-20729		0.0-5.0									Sandy Clay	CL	
AH-200	S-20730		5.0-9.0									Sandy Clay	CL	Rock @ 9'
AH-201	S-20731		0.0-5.0									Sandy Clay	CL	
AH-201	S-20732		5.0-9.0	0	8	92		47	30	14		Clay	CL	
AH-201	S-20733		9.0-11.0	56	31	13		19	3	3		Silty Sandy Gravel	GM	Sand & Gravel @ 9', hole caved
AH-202	S-20734		0.0-5.0									Sandy Clay	CL	
AH-202	S-20735		5.0-10.0									Sandy Clay	CL	
AH-202	S-20736		10.0-12.0									Clayey Sand	SC	Rock @ 12'
AH-203	S-20737		0.0-5.0	0	33	67		34	18	10		Sandy Clay	CL	
AH-203	S-20738		5.0-10.0									Sandy Clay	CL	
AH-203	S-20739		10.0-11.0	1	64	35		23	7	3		Clayey Sand	SC-SM	Rock @ 11', hole caved

TABLE NO. 1 (CONT'D)
SUMMARY OF CLASSIFICATION TESTS
BORROW AREA B-1

HOLE NO.	DISTRICT LAB. NO.	LOCATION	DEPTH (FT)	MECHANICAL ANALYSIS GRAVEL %	SAND %	FINES %	D_{10} mm	ATTERBERG LIMITS LL %	PI %	SL %	FIELD MOIST %	CLASSIFICATION ABJ	LAB	REMARKS FROM DRILLERS LOG
AB-204	S-20740	See Plate No. 1	0.0-5.0								6.5	Sandy Clay	CL	
AB-204	S-20741	for Location	5.0-10.0								6.7	Sandy Clay	CL	
AB-204	S-20742	of Auger Holes	10.0-15.0								5.1	Sandy Clay	CL	
AB-204	S-20743		15.0-20.0								8.2	Sandy Clay	CL	
AB-205	S-20744		0.0-5.0									Sandy Clay	CL	
AB-205	S-20745		5.0-10.0									Sandy Clay	CL	
AB-205	S-20746		10.0-15.0									Sandy Clay	CL	
AB-205	S-20747		15.0-18.0									Sandy Clay	CL	Rock @ 18'
AB-206	S-20748		0.0-5.0	0	48	52		25	10	7	5.9	Sandy Clay	CL	
AB-206	S-20749		5.0-10.0	0	15	85		33	17	11	9.7	Clay	CL	
AB-206	S-20750		10.0-12.0									Clay	CL	
AB-206	S-20751		12.0-15.0								4.4	Clay	CL	Rock @ 15'
AB-207	S-20752		0.0-5.0									Sandy Clay	CL	
AB-207	S-20753		5.0-10.0									Sandy Clay	CL	
AB-207	S-20754		10.0-14.0									Sandy Clay	CL	Rock @ 14'
AB-208	S-20755		0.0-5.0									Sandy Clay	CL	
AB-208	S-20756		5.0-10.0	0	42	58		25	8	5		Sandy Clay	CL	
AB-208	S-20757		10.0-14.0									Sandy Clay	CL	Rock @ 14'
AB-209	S-20758		0.0-5.0									Sandy Clay	CL	
AB-209	S-20759		5.0-10.0									Clay	CL	
AB-209	S-20760		10.0-12.0									Sandy Clay	CL	Rock @ 12'
AB-210	S-20761		0.0-5.0	9	28	63		30	13	8	6.9	Sandy Clay	CL	
AB-210	S-20762		5.0-10.0	2	27	71		31	14	10	7.0	Sandy Clay	CL	
AB-210	S-20763		10.0-15.0								10.6	Sandy Clay	CL	
AB-210	S-20764		15.0-20.0								10.8	Sandy Clay	CL	
AB-211	S-20765		0.0-4.0									Clayey Sandy Gravel	GC	Large rock on surface
AB-212	S-20766		0.0-5.0								8.3	Sandy Clay	CL	
AB-212	S-20767		5.0-10.0								6.6	Sandy Clay	CL	
AB-212	S-20768		10.0-12.0									Sandy Clay	CL	Rock @ 12'
AB-214	S-20769		0.0-4.0	40	32	28		30	13	8		Clayey Sandy Gravel	GC	Rock @ 4'
AB-216	S-20770		0.0-5.0	0	46	54		25	9	6		Sandy Clay	CL	
AB-216	S-20771		5.0-7.0	22	29	49		26	6	5		Clayey Gravelly Sand	SC-SM	Sand & Gravel @ 5', hole caved
AB-217	S-20772		0.0-5.0	0	50	50		27	11	7		Sandy Clay	CL	
AB-217	S-20773		5.0-10.0	0	17	83		37	20	12		Sandy Clay	CL	
AB-217	S-20774		10.0-15.0									Clay	CL	
AB-217	S-20775		15.0-20.0									Clay	CL	
AB-218	S-20776		0.0-5.0									Sandy Clay	CL	
AB-218	S-20777		5.0-10.0									Sandy Clay	CL	
AB-218	S-20778		10.0-15.0									Sandy Clay	CL	
AB-218	S-20779		15.0-20.0									Sandy Clay	CL	
AB-219	S-20780		0.0-5.0	0	18	82		35	17	11		Clay	CL	
AB-219	S-20781		5.0-10.0	8	44	48		28	13	8		Clayey Sand	SC	Rock @ 10'
AB-220	S-20782		0.0-5.0	0	11	89		35	17	11		Clay	CL	
AB-220	S-20783		5.0-8.0	0	20	80		32	14	9		Clay	CL	Rock @ 8'
AB-221	S-20784		0.0-3.0									Clayey Sand	SC	Rock on surface
AB-222	S-20785		0.0-5.0								7.1	Sandy Clay	CL	
AB-222	S-20786		5.0-10.0								4.3	Sandy Clay	CL	
AB-222	S-20787		10.0-15.0								7.9	Clayey Sand	SC	
AB-222	S-20788		15.0-20.0								7.0	Sandy Clay	CL	
AB-223	S-20789		0.0-2.0									Clayey Sandy Gravel	GC	Rock on surface
AB-224	S-20790		0.0-5.0									Sandy Clay	CL	
AB-224	S-20791		5.0-10.0									Sandy Clay	CL	
AB-224	S-20792		10.0-15.0									Sandy Clay	CL	
AB-224	S-20793		15.0-20.0									Sandy Clay	CL	
AB-225	S-20794		0.0-5.0	2	58	40		31	18	9		Clayey Sand	SC	
AB-225	S-20795		5.0-10.0	1	30	69		51	32	16		Sandy Clay	CH	
AB-225	S-20796		10.0-12.0	2	61	37		24	11	6		Clayey Sand	SC	Sand @ 10', hole caved
AB-226	S-20797		0.0-5.0									Sandy Clay	CL	
AB-226	S-20798		5.0-10.0									Sandy Clay	CL	
AB-226	S-20799		10.0-12.0									Clayey Sand	SC	Sand @ 10', hole caved
AB-227	S-20800		0.0-5.0	18	44	38		20	11	7	4.6	Clayey Gravelly Sand	SC	
AB-227	S-20801		5.0-9.0									Clayey Gravelly Sand	SC	Sand @ 9', hole caved
AB-228	S-20802		0.0-5.0									Clayey Sand	SC	
AB-228	S-20803		5.0-10.0									Clayey Sand	SC	
AB-228	S-20804		10.0-15.0									Clayey Sand	SC	
AB-228	S-20805		15.0-20.0	3	54	43		18	9	4		Clayey Sand	SC	

TABLE NO. 1 (CONT'D)
SUMMARY OF CLASSIFICATION TESTS
BORROW AREA B-1

HOLE NO.	DISTRICT LAB. NO.	LOCATION	DEPTH (FT)	MECHANICAL ANALYSIS GRAVEL %	SAND %	FINES %	D_{10} mm	ATTERBERG LIMITS LL %	PI %	LS %	FIELD MOIST	CLASSIFICATION ADJ	LTR	REMARKS FROM DRILLING LOG
AR-233	57668	See Plate No. 1	0-5	0	24	76		29	16	9		Sandy Clay	CL	
AR-233	57669	for Location of	5-10	0	24	76		28	15	9		Sandy Clay	CL	
AR-233	57670	Auger Holes.	10-12	0	23	77		30	16	10	9.8	Sandy Clay	CL	
AR-233	57671		12-14	0	29	71		27	13	9		Sandy Clay	CL	Gravel Bed @14.0'
AR-234	57672		0-5								7.8	Sandy Clay	CL	Gravel Bed @5.0'
AR-235	57673		0-2								9.7	Sandy Clay	CL	Gravel Bed with Cobbles to 3" @ 2.0'
AR-236	57674		0-4	0	20	80		34	20	10	8.4	Sandy Clay	CL	Gravel Bed @4.0'
AR-237	57675		0-3								3.2	Sandy Clayey Gravel	GC	Hard drilling due to large gravels-Refusal @ 3.0'
AR-238	57676		0-4								7.2	Clayey Sand	SC	Gravel Bed @ 4.0'
AR-239	57677		0-2								5.9	Sandy Clay	CL	Gravel Bed with large Cobbles @ 2.0'
AR-240	57678		0-5									Sandy Clay	CL	
AR-240	57679		5-8									Clayey Sand	SM-SC	
AR-240	57680		8-10								2.1	Silty Sand	SP-SM	Holes caved @10.0'
AR-241	57681		0-6								7.3	Sandy Clay	CL	Gravel Bed @ 6.0'
AR-247	57692		0-5	0	16	84		34	20	10		Sandy Clay	CL	
AR-247	57693		5-11	0	31	69		26	14	5	6.3	Sandy Clay	CL	Gravel Bed @ 11.0'
AR-248	57694		0-5								5.7	Clayey Sand	SC	Gravel Bed @ 5.0'
AR-249	57695		0-5	1	17	82		30	16	9		Sandy Clay	CL	
AR-249	57696		5-8	0	36	64		23	10	5	4.9	Sandy Clay	CL	Gravel Bed @ 8.0'
AR-250	57697		0-2								6.0	Clayey Sand	SC-SM	Gravel Bed @ 2.0', large gravels on surface
T-1		See Plate No. 1		66	32	2	0.30					Sandy Gravel	GW	9' Sand & Gravel
T-3		for Locations												6' Sand & Gravel
T-4		of Trenches &												10' Sand & Gravel
T-5		Drill Holes		74	24	2	0.45					Sandy Gravel	GP	6' Sand & Gravel
T-6				71	26	3	0.37					Sandy Gravel	GW	7' Sand & Gravel
T-7				54	44	2	0.34					Sandy Gravel	GP	6' Sand & Gravel
T-8				58	40	2	0.29					Sandy Gravel	GP	3'¢ Sand & Gravel
T-9				69	29	2	0.30					Sandy Gravel	GW	3'¢ Sand & Gravel
T-10														8' Sand & Gravel
T-11				72	25	3	0.44	19	2	3		Sandy Gravel	GW	12' Sand & Gravel
T-12														8' Sand & Gravel
T-13														6'¢ Sand & Gravel
T-14				59	38	3	0.25					Sandy Gravel	GP	5.5' Sand & Gravel
T-15														10' Sand & Gravel
T-16				62	36	2	0.29					Sandy Gravel	GP	10' Sand & Gravel
T-17														10' Sand & Gravel
T-18				70	28	2	0.36					Sandy Gravel	GW	7' Sand & Gravel
T-19														5' Sand & Gravel
T-20				82	17	1	0.42					Sandy Gravel	GP	9' Sand & Gravel
T-21				40	57	3	0.18					Gravelly Sand	SW	4' Sand & Gravel
T-23														8' Sand & Gravel
T-24														17' Sand & Gravel
T-25				67	32	1	0.36					Sandy Gravel	GW	15' Sand & Gravel
T-26														11' Sand & Gravel
T-27				66	32	2	0.23					Sandy Gravel	GP	10' Sand & Gravel
T-28														6' Sand & Gravel
T-29														7' Sand & Gravel
T-30				63	35	2	0.38					Sandy Gravel	GP	7' Sand & Gravel
T-31														8.5' Sand & Gravel
T-32														8' Sand & Gravel
T-33														6' Sand & Gravel
T-34														4' Sand & Gravel
T-35				67	32	1	0.52					Sandy Gravel	GP	2' Overburden, 5' Sand & Gravel
T-43	57903			65	30	5	0.29					Sandy Gravel	GP-GM	7.0' Sand & Gravel
				(1) 0	86	14						Silty Sand	SC	
T-44	57904		2.5-10.5	70	28	2	0.40					Sandy Gravel	GP	8.0' Sand & Gravel
				(1) 0	92	8	0.11					Sand	SP-SM	
DH-2														32' Overburden, 6' Sand & Gravel
DH-3														20' Overburden, 8' Sand & Gravel
DH-4														6' Overburden, 8' Sand & Gravel
DH-5														7' Overburden, 9' Sand & Gravel
DH-6														3' Overburden, 8' Sand & Gravel
DH-7														23' Overburden 6' Sand & Gravel
DH-13														4' Overburden 10' Sand & Gravel

NOTE: Drilling logs of auger holes in Borrow Area B-1 which did not penetrate the full 20-foot depth show that the depth of investigation was limited by rock, sand and gravel, cobbles, rocks and caving of the holes. It is believed that gravel and cobble sizes in the underlying sand and gravel deposits, explored and outlined by the trenches and "fishtail" drill holes, prevented maximum depth exploration in these areas.

(1) Wt. as a fraction of Sample.

TABLE NO. 2
SUMMARY OF CLASSIFICATION TESTS
BORROW AREA B-2

HOLE NO.	DISTRICT LAB. NO.	LOCATION	DEPTH (FT)	MECHANICAL ANALYSIS GRAVEL %	SAND %	FINES %	D_{10} mm	ATTERBERG LIMITS LL %	PI %	LS %	FIELD MOIST %	CLASSIFICATION ADJ	LAB	REMARKS FROM DRILLERS LOG
AB-98	49006	See Plate No. 1	0.0-1.0									Sandy Silt	ML	
AB-98	49007	for location of	1.0-2.0									Clayey Silt	ML-CL	
AB-98	49008	Auger Holes	2.0-4.0	0	14	86		32	11	6		Silty Clay	CL	
AB-98	49009		4.0-5.0									Gravelly Silty Sand	GM	Rock @ 5.5', appears to be solid
AB-99	49010		0.0-3.0	0	51	49		21	6	4		Clayey Sand	SC-SM	
AB-99	49011		3.0-11.0									Silty Clay	CL-ML	
AB-99	49012		11.0-17.0									Silty Clay	CL-ML	
AB-99	49013		17.0-19.0									Sandy Clay	CL-ML	
AB-99	49014		19.0-20.0									Sandy Clay	CL-ML	Rock @ 20'
AB-100	49015		0.0-2.0									Silty Clay	CL-ML	
AB-100	49016		2.0-3.0									Sand Silt Gravel	GM	
AB-100	49017		3.0-5.5	23	63	14		19	3	4		Gravelly Silty Sand	SM	Rock @ 5.5'
AB-101	49018		0.0-2.0									Sandy Silt	ML-CL	
AB-101	49019		2.0-7.0	26	41	33						Gravelly Clayey Sand	SC	Rock @ 7.0'
AB-102	49020		0.0-5.0									Sandy Clay	CL-ML	
AB-102	49021		5.0-10.0									Sandy Clay	CL-ML	
AB-102	49022		10.0-12.0									Lean Clay	CL	
AB-102	49023		12.0-14.0									Clayey Silt	ML-CL	Rock @ 14'
AB-103	49024		0.0-5.0	0	42	58		21	4	3		Sandy Silt	ML-CL	
AB-103	49025		5.0-11.0									Clayey Silt	ML	
AB-103	49026		11.0-16.0	1	33	66		24	10	9		Sandy Clay	CL	
AB-103	49027		16.0-20.0									Sandy Clay	CL	
AB-104	49028		0.0-1.0	6	35	59		21	6	4		Sandy Clay	CL-ML	
AB-104	49029		1.5-3.5									Silty Clay	CL	
AB-104	49030		3.5-6.0					19	3	3		Silty Sand	SM	
AB-104	49031		6.0-11.0									Silty Clay	CL-ML	
AB-104	49032		11.0-16.0	0	25	75		30	15	13		Sandy Clay	CL	
AB-104	49033		16.0-20.0									Silty Sand	SM	
AB-105	49034		0.0-4.0	7	55	38		20	3	3		Silty Sand	SM	
AB-105	49035		4.0-6.5									Sandy Clay	CL-ML	
AB-105	49036		6.5-11.0									Silty Clay	CL-ML	
AB-105	49037		11.0-20.0									Silty Clay	CL-ML	
AB-106	49038		0.0-3.0	2	54	44						Silty Sand	SM	
AB-106	49039		3.0-6.0									Sandy Clay	CL-ML	
AB-106	49040		6.0-6.5									Sandy Silt	ML	Rock @ 6.5', appears to be solid
AB-107	49041		0.0-5.0	1	55	45		20	4	4		Silty Sand	SM-SC	
AB-107	49042		5.0-7.0									Sandy Clay	CL	Rock @ 7.0'
AB-108	49043		0.0-4.0	0	49	51		23	7	5		Sandy Clay	CL-ML	
AB-108	49044		4.0-6.5									Sandy Clay	CL	
AB-108	49045		6.5-10.0									Sandy Clay	CL	Rock @ 10.0', hole caved
AB-109	49046		0.0-5.0									Sandy Clay	CL	Rock @ 5.0'
AB-110	49047		0.0-5.5	0	34	66		27	12	9		Sandy Clay	CL	
AB-110	49048		5.5-13.5									Sandy Clay	CL	
AB-110	49049		13.5-15.0									Sandy Clay	CL	
AB-110	49050		15.0-16.0									Clayey Silt	ML-CL	
AB-110	49051		16.0-17.0									Clayey Silt	ML-CL	Rock @ 17.0', appears to be solid
AB-111	49052		0.0-1.0	0	47	53		27	7	7		Sandy Clay	CL-ML	
AB-111	49053		1.0-5.0									Sandy Clay	CL-ML	
AB-111	49054		5.0-7.0									Sandy Clay	CL	
AB-111	49056		7.0-10.0									Sandy Clay	CL	Rock @ 10.0'
AB-112	49057		0.0-5.0									Sandy Clay	CL	
AB-112	49058		5.0-6.0									Sandy Clay	CL	
AB-112	49059		6.0-9.0									Lean Clay	CL	
AB-112	49060		9.0-17.5									Sandy Clay	CL	
AB-112	49061		17.5-20.0	0	22	78		28	9	9		Sandy Clay	CL	
AB-229			0.0-0.5									Sandy Clay	CL	
AB-229	51211		0.5-6.0	82	15	3	.71					Sandy Gravel	GP	
AB-229	51212		6.0-10.0	70	25	5	.30					Sandy Gravel	GP	Sampled from old Test Pit
AB-230			0.0-1.0									Sandy Silt	ML-CL	
AB-230	51213		1.0-6.0	79	17	4	.42					Sandy Gravel	GP	
AB-230	51214		6.0-10.0	79	16	5	.22					Sandy Gravel	GP	Sampled from old Test Pit
AB-231	51215		0.0-5.0	72	25	3	.17					Sandy Gravel	GP	
AB-231	51216		5.0-8.0	68	22	10	.075					Sandy Gravel	GP-GM	Hole caved
AB-232			0.0-3.0									Sandy Clay	CL-ML	
AB-232	51217		3.0-7.0	47	41	12	.070					Sandy Gravel	GP-GM	Hole caved
Area 1	51219			80	14	6	.50					Sandy Gravel	GP-GM	Sampled from 10' exposed face
Area 2	51220			78	15	7	.15					Sandy Gravel	GP-GM	Sampled from 10' exposed face
Area 3	51221			80	17	3	.46					Sandy Gravel	GP	Sampled from placer mine waste pit
Area 4	51222			73	24	3	.39					Sandy Gravel	GP	Sampled from old test pit

NOTE: Drilling logs of auger holes in Borrow Area B-2 show that the depth of investigation was limited by cobbles, rock, solid rock and caving of the holes. Geologic reconnaissance of the area indicates that gravel and cobble sizes of the underlying sand and gravel deposits limited the depth of exploration.

TABLE NO. 2 (CONT'D)
SUMMARY OF CLASSIFICATION TESTS
BORROW AREA B-2

HOLE NO.	DISTRICT LAB. NO.	LOCATION	DEPTH (FT)	MECHANICAL ANALYSIS GRAVEL %	SAND %	FINES %	D_{10} mm	ATTERBERG LIMITS LL %	PI %	LS %	FIELD MOIST %	CLASSIFICATION [illegible]	LTR	REMARKS
T-45	57905	See Plate No. 1 for Location of Trenches	2.5-9.5	54 (1) 0	32 69	14 31						Sandy Gravel Clayey Sand	GC SC	7' Sand & Gravel
T-46	57906		0.0-5.5	68 (1) 0	26 82	6 18	0.15					Sandy Gravel Silty Sand	GP-GM SM	5.5' Sand & Gravel
T-47	57907		3.0-10.0	73 (1) 0	24 90	3 10	0.25 0.076					Sandy Gravel Sand	GW SP-SM	7' Sand & Gravel
T-49	57908		0.7-10.0	66 (1) 0	26 76	8 24	0.10					Sandy Gravel Silty Sand	GP-GM SM	9.3' Sand & Gravel
T-50	57909		0.0-16.0	73 (1) 0	23 85	4 15	0.30					Sandy Gravel Silty Sand	GM SM	16' Sand & Gravel
T-51	57910		1.5-10.0	58 (1) 0	37 88	5 12	0.21					Sandy Gravel Silty Sand	GP-GM SP-SM	8.5' Sand & Gravel
T-52	57911		1.0-8.5	71 (1) 0	27 93	2 7	0.37 0.12					Sandy Gravel Sand	GP SP-SM	7.5' Sand & Gravel
T-53	57912		1.0-8.0	71 (1) 0	25 86	4 14	0.29					Sandy Gravel Silty Sand	GP SM	7' Sand & Gravel

(1) Minus No. 4 fraction of sample.

TABLE NO. 3
SUMMARY OF CLASSIFICATION TESTS
BORROW AREA B-3

HOLE NO.	DISTRICT LAB. NO.	LOCATION	DEPTH (FT)	MECHANICAL ANALYSIS GRAVEL %	SAND %	FINES %	D_{10} mm	ATTERBERG LIMITS LL %	PI %	LS %	FIELD MOIST %	CLASSIFICATION ADJ	LTR	REMARKS FROM DRILLERS LOG
AH-1	44153	See Plate No. 1 for Location of Auger Holes	0.0-2.5	2	40	58		27	8	6	6	Silty Clay	CL	Rock @ 2.5'
AH-2	44154		0.0-5.0	0	26	74		28	12	9	9	Silty Clay	CL	
AH-2	44155		5.0-7.0	0	23	77		28	8	11		Silty Clay	CL	Rock @ 7'
AH-3	44156		0.0-0.5	1	31	68		24	7	6		Silty Clay	CL-ML	
AH-3	44157		0.5-1.5	0	35	65		31	10	10		Silty Clay	CL	
AH-3	44158		1.5-3.5	2	54	44		29	8	7	4	Clayey Sand	SC	Rock @ 3.5'
AH-4	44159		0.0-1.0	0	36	64		33	18	6		Sandy Clay	CL	
AH-4	44160		1.0-2.5	2	21	71		29	9	9		Silty Clay	CL	
AH-4	44161		2.5-4.0	2	24	74		35	14	11		Silty Clay	CL	
AH-4	44162		4.0-7.0	0	30	70		33	14	10	8	Silty Clay	CL	Rock @ 7'
AH-5	44163		0.0-1.0	0	25	75		22	5	5		Sandy Silt	ML-CL	
AH-5	44164		1.0-3.5	0	15	85		35	14	11		Silty Clay	CL	
AH-5	44165		3.5-4.5	22	21	57		32	12	11		Gravelly Sandy Clay	CL	
AH-5	44166		4.5-6.0	0	41	59		25	6	4	3	Silty Clay	CL-ML	Rock @ 6'
AH-6	44167		0.0-5.0	1	38	61		21	5	4		Sandy Silt	ML-CL	
AH-6	44168		0.5-2.0	4	41	55		23	5	6		Sandy Silt	ML-CL	Rock @ 2'
AH-7	44169		0.0-1.5	8	29	63		23	5	5		Sandy Silt	ML-CL	
AH-7	44170		1.5-4.0	1	17	82		30	14	8		Sandy Clay	CL	
AH-7	44171		4.0-5.0	3	20	77		29	11	8	7	Sandy Clay	CL	Rock @ 5'
AH-8	44172		0.0-1.5	8	50	42		16	2	2		Silty Sand	SM	
AH-8	44173		1.5-3.0	2	43	55		24	9	9		Silty Clay	CL	
AH-8	44174		3.0-4.0	8	50	42		21	5	3		Silty Sand	SM-SC	
AH-8	44175		4.0-6.0	14	35	51		24	7	9	5	Silty Clay	CL-ML	Rock @ 6'
AH-9	44176		0.0-2.0	3	74	23		16	1	2		Silty Sand	SM	
AH-9	44177		2.0-3.0	0	53	47		18	2	6		Silty Sand	SM	Rock @ 3'
AH-10	44178		0.0-1.5	0	66	34		17	2	2		Silty Sand	SM	
AH-10	44179		1.5-3.0	0	51	49						Silty Sand	SM	
AH-10	44180		3.0-5.5	0	70	30		19	3	3	3	Silty Sand	SM	Rock @ 5.5'
AH-11	44181		0.0-2.0	3	43	54		19	5	4		Sandy Silt	ML-CL	
AH-11	44182		2.0-3.0	14	36	50		28	8	9		Clayey Sand	SC	
AH-11	44183		3.0-4.5	3	48	49		26	9	7		Clayey Sand	SC	Rock @ 4.5'
AH-12	44184		0.0-2.0	5	43	52		20	2	4		Sandy Silt	ML	
AH-12	44185		2.0-3.5	4	38	58		23	5	9		Sandy Silt	ML-CL	Rock @ 3.5', believed to be small boulders
AH-13	44186		0.0-1.5	0	45	55		20	5	3		Sandy Silt	ML-CL	
AH-13	44187		1.5-3.5	2	52	46		24	6	6		Clayey Sand	SC-SM	
AH-13	44188		3.5-5.0	10	55	35		22	8	4	3	Clayey Sand	SC	Rock @ 5'
AH-14	44189		0.0-1.0	3	49	48		20	4	5		Silty Sand	SM-SC	
AH-14	44190		1.0-2.5	2	52	46		23	7	5		Clayey Sand	SC-SM	
AH-14	44191		2.5-4.0	7	61	32		21	5	3	2	Silty Sand	SM-SC	Rock @ 4'
AH-15	44192		0.0-1.0	9	37	54		20	3	4		Sandy Silt	ML	
AH-15	44193		1.0-3.0	2	27	71		34	17	12		Sandy Clay	CL	Rock @ 3'
AH-16	44194		0.0-1.0	7	35	58		20	4	5		Sandy Silt	ML-CL	
AH-16	44195		1.0-4.0	7	34	59		27	10	8		Silty Clay	CL	Rock @ 4'
AH-17	44196		0.0-1.0	0	40	60		22	7	5		Silty Clay	CL-ML	
AH-17	44197		1.0-3.0	0	32	68		25	7	8		Silty Clay	CL-ML	
AH-17	44198		3.0-4.5	10	19	71		30	13	12		Sandy Clay	CL	
AH-17	44199		4.5-6.0	1	53	46		24	10	8	6	Clayey Sand	SC	Rock @ 6'
AH-18	44200		0.0-1.0	4	39	57		20	3	5		Sandy Silt	ML	
AH-18	44201		1.0-4.0	12	42	46		23	5	8		Silty Sand	SM-SC	Rock @ 4'
AH-19	44202		0.0-1.0	0	33	67		19	4	6		Sandy Silt	ML-CL	
AH-19	44203		1.0-3.0	6	36	58		29	12	10		Sandy Clay	CL	Rock @ 3'
AH-20	44204		0.0-1.0	0	30	70		32	12	10		Silty Clay	CL	
AH-20	44205		1.0-2.0	0	16	84		30	10	9		Silty Clay	CL	
AH-20	44206		2.0-3.5	3	33	64						Silty Clay	CL	
AH-20	44207		3.5-4.5	1	47	52						Silty Clay	CL	
AH-20	44208		4.5-7.0	2	52	46		23	7	8	9	Clayey Sand	SC-SM	Rock @ 7'
AH-21	44209		0.0-1.0	1	40	59		26	8	8		Silty Clay	CL	
AH-21	44210		1.0-2.5	0	25	75		29	11	10		Silty Clay	CL	
AH-21	44211		2.5-4.0	1	37	62		28	11	10		Silty Clay	CL	
AH-21	44212		4.0-6.5	1	42	57		27	10	6		Silty Clay	CL	
AH-21	44213		6.5-9.0	1	44	55		30	13	9	6	Sandy Clay	CL	Rock @ 9'
AH-22	44214		0.0-1.0	0	45	55		19	4	5		Sandy Silt	ML-CL	
AH-22	44215		1.0-2.5	0	19	81		28	10	9		Silty Clay	CL	
AH-22	44216		2.5-3.0	0	26	74		24	10	9		Silty Clay	CL	
AH-22	44217		3.0-4.5	0	38	62		21	9	6		Silty Clay	CL	
AH-22	44218		4.5-5.5	2	33	65		26	11	9		Silty Clay	CL	
AH-22	44219		5.5-7.0	0	35	65		21	8	6	4	Silty Clay	CL	Rock @ 7'
AH-23	44220		0.0-1.5	2	29	69		19	3	5		Sandy Silt	ML	
AH-23	44221		1.5-3.0	7	25	68		29	12	11		Sandy Clay	CL	
AH-23	44222		3.0-4.5	10	32	58		25	8	10		Silty Clay	CL	Rock @ 4.5'
AH-24	44223		0.0-1.0	0	16	84		27	9	9		Silty Clay	CL	
AH-24	44224		1.0-3.0	1	11	88		30	9	9		Silty Clay	CL	
AH-24	44225		3.0-4.5	1	27	72		27	11	9		Sandy Clay	CL	
AH-24	44226		4.5-5.5	1	29	70		28	14	11	7	Sandy Clay	CL	Rock @ 5.5'

TABLE NO. 3 (CONT'D)
SUMMARY OF CLASSIFICATION TESTS
BORROW AREA B-3

HOLE NO.	DISTRICT LAB. NO.	LOCATION	DEPTH (FT)	MECHANICAL ANALYSIS GRAVEL %	SAND %	FINES %	D_{10} mm	ATTERBERG LIMITS LL %	PI %	LS %	FIELD MOIST %	CLASSIFICATION ADJ	U/M	REMARKS FROM DRILLERS LOG
AB-25	44227	See Plate No. 1	0.0-1.0	2	27	71		20	6	6		Silty Clay	CL-ML	
AB-25	44228	for Location of	1.0-3.5	0	19	81		29	10	8		Silty Clay	CL	
AB-25	44229	Auger Holes	3.5-5.0	2	22	76		28	11	9		Sandy Clay	CL	
AB-25	44230		5.0-7.0	1	24	75		29	14	11		Sandy Clay	CL	
AB-25	44231		7.0-9.0	1	23	76		26	11	9	6	Sandy Clay	CL	Rock @ 9'
AB-26	44232		0.0-1.0	10	25	65		21	6	4		Silty Clay	CL-ML	
AB-26	44233		1.0-2.5	0	31	69		33	11	9		Silty Clay	CL	
AB-26	44234		2.5-4.0	2	17	81		37	19	10		Lean Clay	CL	
AB-26	44235		4.0-5.0	1	25	74		29	11	6	7	Silty Clay	CL	Rock @ 5'
AB-27	44236		0.0-1.5	0	49	51		20	3	2		Sandy Silt	ML	
AB-27	44237		1.5-3.0	0	29	71		24	9	9		Silty Clay	CL	
AB-27	44238		3.0-4.5	0	19	81		28	11	9		Lean Clay	CL	
AB-27	44239		4.5-6.0	1	44	55					5	Silty Clay	CL	
AB-27	44240		6.0-7.5	2	56	42		21	3	4		Silty Sand	SM	
AB-27	44241		7.5-10.0	0	31	69		28	11	10		Sandy Clay	CL	Rock @ 10'
AB-28	44242		0.0-1.0	7	29	64		22	5	3		Sandy Silt	ML-CL	
AB-28	44243		1.0-3.5	0	20	80		30	11	11		Silty Clay	CL	
AB-28	44244		3.5-5.5	2	58	40		22	5	4	4	Silty Sand	SM-SC	Soft Rock @ 4.5' Hard Rock @ 5.5'
AB-29	44245		0.0-1.5	0	41	59		22	7	5		Silty Clay	CL-ML	
AB-29	44246		1.5-4.0	1	22	77		31	11	9		Silty Clay	CL	
AB-29	44247		4.0-6.0	0	47	53		23	5	2	7	Sandy Silt	ML-CL	
AB-29	44248		6.0-11.0	7	51	42						Silty Sand	SM	Soft Rock 6'-11.0', unable to drill thru it
AB-30	44249		0.0-2.0	7	58	35		16	NP	3		Silty Sand	SM	
AB-30	44250		2.0-3.5	0	33	67		24	8	7		Silty Clay	CL	
AB-30	44251		3.5-5.5	5	34	61		30	12	9	7	Sandy Clay	CL	Rock @ 5.5'
AB-31	44252		0.0-1.5	0	40	60		20	4	4		Sandy Silt	ML-CL	
AB-31	44253		1.5-3.0	0	32	68		25	9	8		Silty Clay	CL	Rock @ 3'
AB-33	44254		0.0-2.0	0	47	53		18	4	4		Sandy Silt	ML-CL	
AB-33	44255		2.0-3.5	0	30	70		28	13	7		Sandy Clay	CL	
AB-33	44256		3.5-5.0	0	30	70		27	9	9		Silty Clay	CL	
AB-33	44257		5.0-6.0	5	28	67		23	8	8	7	Silty Clay	CL	Rock @ 6'
AB-34	44258		0.0-1.0	1	57	42		16	1	3		Silty Sand	SM	
AB-34	44259		1.0-2.5	0	50	50		26	10	8		Clayey Sand	SC	Rock @ 2.5'
AB-35	44260		0.0-2.0	3	50	47		19	5	4		Silty Sand	SM-SC	
AB-35	44261		2.0-3.5	5	45	50		25	6	7		Clayey Sand	SC-SM	Rock @ 3.5', Rock out crops on surface
AB-39	44262		0.0-2.0	0	66	34		20	2	2		Silty Sand	SM	
AB-39	44263		2.0-4.5	1	57	42		24	4	4		Silty Sand	SM-SC	
AB-39	44264		4.5-6.0	3	39	58		25	9	7	6	Silty Sand	CL	Rock @ 6'
AB-40	44265		0.0-2.0	5	55	40		21	6	5		Clayey Sand	SC-SM	
AB-40	44266		2.0-3.0	4	52	44		25	7	7		Clayey Sand	SC-SM	Rock @ 3'
AB-51	44285		0.0-2.0	11	42	47		20	3	4		Silty Sand	SM	
AB-51	44286		2.0-4.0	19	41	40		26	8	7		Clayey, Gravelly Sand	SC	
AB-51	44287		4.0-5.0	8	52	40		22	5	6		Silty Sand	SM-SC	Rock @ 5'
AB-52	44288		0.0-1.0	2	35	63		24	7	6		Silty Clay	CL-ML	
AB-52	44289		1.0-2.5	0	23	77		29	10	7	7	Silty Clay	CL	
AB-52	44290		2.5-4.0	11	37	52		26	9	9		Silty Clay	CL	
AB-52	44291		4.0-6.0	35	37	28		24	7	6		Clayey Gravelly Sand	SC-SM	Rock @ 6'
AB-54	44292		0.0-1.0	28	26	46		26	10	7		Clayey, Sandy Gravel	GC	Small boulders 0-6', unable to drill deeper
AB-54	44293		1.0-6.0	9	40	51		40	15	11		Silty Clay	CL	
AB-55	44294		0.0-1.0	8	25	67		23	6	7		Silty Clay	CL-ML	
AB-55	44295		1.0-3.0	1	28	71		39	17	14		Silty Clay	CL	
AB-55	44296		3.0-4.5	4	22	74		37	15	9	10	Silty Clay	CL	Rock @ 4.5'
AB-56	44297		0.0-1.0	31	19	50		25	7	8		Clayey, Sandy Gravel	GC-GM	
AB-56	44298		1.0-2.0	11	19	70		39	20	11		Sandy Clay	CL	
AB-56	44299		2.0-3.5	16	27	57		38	14	10		Gravelly, Silty Clay	CL	
AB-56	44300		3.5-5.0	10	42	48		40	15	8	9	Clayey Sand	SC	
AB-56	44301		5.0-7.0	72	15	13		32	11	6		Clayey, Sandy Gravel	GC	
AB-57	44329		0.0-6.0	8	12	80		49	24	17		Silty Clay	CL	
AB-57	44330		6.0-12.0	0	14	86		58	37	23		Fat Clay	CH	
AB-57	44331		12.0-18.0	0	14	86		56	30	21		Fat Clay	CH	
AB-57	44332		18.0-24.0	0	1	99		61	37	21	7	Fat Clay	CH	
AB-58	44333		0.0-1.0	35	26	39		27	5	0		Silty, Sandy Gravel	GM-GC	
AB-58	44334		1.0-4.0	4	21	75		34	15	13		Sandy Clay	CL	
AB-58	44335		4.0-6.0	0	17	83		45	25	22		Sandy Clay	CL	
AB-58	44336		6.0-8.0	0	19	81		42	24	19	6	Sandy Clay	CL	Rock @ 8'

TABLE NO. 3 (CONT'D)
SUMMARY OF CLASSIFICATION TESTS
BORROW AREA B-3

HOLE NO.	DISTRICT LAB. NO.	LOCATION	DEPTH (FT)	MECHANICAL ANALYSIS GRAVEL %	SAND %	FINES %	D_{10} mm	ATTERBERG LIMITS LL %	PI %	SL %	FIELD MOIST %	CLASSIFICATION ADJ	LTR	REMARKS FROM DRILLERS LOG
AH-59	44337	See Plate No. 1	0.0-1.0	2	23	75		23	4	5		Sandy Silt	ML-CL	
AH-59	44338	for Location	1.0-2.5	0	14	86		33	12	10		Silty Clay	CL	
AH-59	44339	of Auger Holes	2.5-4.0	0	10	90		36	19	11	10	Lean Clay	CL	
AH-59	44340		4.0-5.5	3	12	85		40	21	13		Lean Clay	CL	Rock @ 5.5'
AH-61	44341		0.0-1.0	0	27	73		24	7	6		Silty Clay	CL-ML	
AH-61	44342		1.0-6.0	0	21	79					7	Silty Clay	CL	
AH-61	44343		6.0-9.0	0	17	83		37	21	12		Lean Clay	CL	Rock @ 6'
AH-62	44344		0.0-1.0	23	31	46		23	5	6		Silty, Gravelly Sand	SM-SC	
AH-62	44345		1.0-3.0	40	33	27						Silty, Sandy Gravel	GM	
AH-62	44346		3.0-5.5	86	8	6		30	9	4		Clayey Sandy Gravel	GC	Cobbles @ 5.5'
AH-64	44347		0.0-1.0	13	32	55		29	10	7		Silty Clay	CL	
AH-64	44348		1.0-5.5	8	25	67		38	21	12		Sandy Clay	CL	Rock @ 5.5'
AH-65	44349		0.0-1.0	29	27	44		28	10	9		Clayey, Sandy Gravel	GC	
AH-65	44350		1.0-4.0	23	30	47						Clayey, Gravelly Sand	SC	Rock @ 4'
AH-66	44351		0.0-1.5	29	28	43						Clayey, Sandy Gravel	GC	
AH-66	44352		1.5-4.0	32	33	35						Clayey, Gravelly Sand	SC	Rock @ 4'
AH-67	44353		0.0-1.0	35	28	37		22	3	0		Silty, Sandy Gravel	GM	
AH-67	44354		1.0-4.0	25	48	27		37	9	3		Silty, Gravelly Sand	SM	Unable to drill through cobbles
AH-68	44355		0.0-1.0	9	36	55		22	5	5		Sandy Silt	ML-CL	
AH-68	44356		1.0-3.0	9	36	55		34	12	9		Silty Clay	CL	
AH-68	44357		3.0-5.5	31	43	26		29	11	4	8	Clayey, Gravelly Sand	SC	Rock @ 5.5'
AH-69	44358		0.0-1.0	5	30	65		22	6	6		Silty Clay	CL-ML	
AH-69	44359		1.0-2.5	0	25	75		36	17	11		Sandy Clay	CL	
AH-69	44360		2.5-4.0	2	28	70		39	17	8		Silty Clay	CL	
AH-69	44361		4.0-5.5	7	29	64		41	16	8	13	Silty Clay	CL	Rock @ 5.5'
AH-70	44362		0.0-1.5	34	30	36		25	7	5		Clayey, Sandy Gravel	GC-GM	
AH-70	44363		1.5-3.0	20	27	53		36	14	11		Gravelly, Silty Clay	CL	Rock @ 3'
AH-72	44364		0.0-2.0	23	53	24		26	6	5		Clayey, Gravelly Sand	SC-SM	
AH-72	44365		2.0-6.0	0	45	55		24	8	9	2	Silty Clay	CL-ML	
AH-72	44366		6.0-10.0	0	8	92						Lean Clay	CL	
AH-73	44367		0.0-1.0	35	25	40						Clayey, Sandy Gravel	GC	
AH-73	44368		1.0-4.0	50	28	22		34	9	7		Silty, Sandy Gravel	GM	Rock @ 4.0'
AH-74	44369		0.0-1.0	31	32	37		25	9	5		Clayey, Gravelly Sand	SC	
AH-74	44370		1.0-3.5	27	26	47		33	8	5		Silty, Sandy Gravel	GM	Rock @ 3.5'
AH-75	44371		0.0-1.5	31	30	39						Clayey, Sandy Gravel	GC	
AH-75	44372		1.5-3.0	18	42	40		35	13	8		Clayey, Gravelly Sand	SC	
AH-75	44373		3.0-4.5	20	47	33		31	8	6	7	Silty, Gravelly Sand	SM	Rock @ 4.5'
AH-76	44374		0.0-1.0	32	24	44						Silty, Sandy Gravel	GM	
AH-76	44375		1.0-3.0	35	24	41					9	Silty, Sandy Gravel	GM	
AH-76	44376		3.0-5.0	84	7	9						Silty, Sandy Gravel	GM	Rock @ 5'
AH-77	44377		0.0-1.0	33	22	45						Clayey, Sandy Gravel	GC	
AH-77	44378		1.0-2.0	11	29	60						Gravelly, Sandy Clay	CL	
AH-77	44379		2.0-5.0	52	20	28						Clayey, Sandy Gravel	GC	Rock @ 5'

NOTE: Drilling logs of auger holes in Borrow Area B-3 show that the depth of the investigation was limited by presence of rock. It is believed that the auger holes reached the sandstone formation in the northeast half of the area and in the southwest half, the depth of auger hole investigation was limited by gravel and cobble sizes in the underlying sand and gravel deposits.

Abiquiu Dam

TABLE NO. 4

Summary of Design, Construction-Control, and Record Sample Data, Embankment and Foundation Materials

Feature	Design Data					Construction-Control Data (Field Tests)		Record Sample Data (SWD Laboratory Tests)				
		Shear Strength							Shear Strength			
	Dry Weight lb/cu ft	Type Test	Angle of Internal Friction ϕ, deg	Cohesion (c) ton/sq ft	Permeability cm/sec	Dry Weight lb/cu ft	Moisture Content %	Dry Weight lb/cu ft	Type Test	Angle of Internal Friction ϕ, deg	Cohesion (c) ton/sq ft	Permeability ft/min
Embankment materials												
Impervious fill	114	Q(T)* R(T) S(DS)	5 14 25	1.0 0.4 0.0	0.5×10^{-6}	102 to 126 111.4 (avg)	7.4 to 17.2 12.3 (avg)	100 to 125 112 (avg) ††	Q(T)** R(T)† S(DS)†	10.5 to 32.4 22.1 to 32.9 24.4 to 31.7	0.4 to 2.1 0.2 to 0.7 0.0 to 0.4	3×10^{-6} to 3×10^{-8} (6 tests)
Random fill	118	Q(T)‡ R(T) S(DS)	12 16 27	1.3 0.5 0.0	0.5×10^{-6}	107 to 132 114.2 (avg)	4.7 to 14.2 10.0 (avg)	107 to 122 115 (avg) §§	Q(T) R(T)§ S(DS)§	‡‡ 23.4 to 31.0 30.4 to 38.5	‡‡ 0.1 to 0.5 0.0 to 0.1	‡‡
Pervious fill	136	S(DS)	35	0.0	500×10^{-4}#	‡‡	10.2	‡‡	‡‡	‡‡	‡‡	‡‡
Required waste fill	100	‡‡	20	0.0	--	‡‡	‡‡	‡‡	‡‡	‡‡	‡‡	‡‡
Foundation materials												
Streambed alluvium	136	S(DS)	35	0.0	500×10^{-4}#	‡‡	‡‡	‡‡	‡‡	‡‡	‡‡	‡‡
Bedrock (interbedded mudstone and sandstone)	139	S(DS)	20	0.0	0.5×10^{-8}#	‡‡	‡‡	‡‡	‡‡	‡‡	‡‡	‡‡

Note: Record sample tests on impervious- and random-fill materials were conducted on undisturbed cylinder samples.
- * Moisture content 2% wetter than optimum.
- ** 13 tests.
- † 9 tests.
- †† 23 undisturbed samples.
- ‡ Optimum moisture content.
- ‡‡ Not tested
- § 7 tests.
- §§ 6 undisturbed samples.
- \# Estimated.

TABLE 5
SURFACE SETTLEMENT AND HORIZONTAL
MOVEMENT POINTS

NO	DATE INITIAL READINGS	INITIAL ELEV (ft)	INITIAL OFFSET (in)	CURRENT	ELEVATION (ft)	OFFSET (in)	DIFFERENCE ELEVATION (ft)	DIFFERENCE IN OFFSET (in)
1	18 Aug 1970	6374.192	0.2U/S	30 Mar 1981	6374.251	1.30/S	+.006	1.5D/S
2	18 Aug 1970	6369.686	0.2U/S	30 Mar 1981	6369.591	0.55D/S	-.095	0.75D/S
3	18 Aug 1970	6368.215	0.2D/S	30 Mar 1981	6368.044	0.0	-.171	0.2U/S
4	18 Aug 1970	6368.163	0.2D/S	30 Mar 1981	6367.926	0.0	-.237	0.2U/S
5	18 Aug 1970	6368.298	0.2D/S	30 Mar 1981	6368.057	0.0	-.241	0.2U/S
6	18 Aug 1970	6368.111	0.3D/S	30 Mar 1981	6367.695	0.3D/S	-.416	0.0
7	18 Aug 1970	6368.120	0.2U/S	30 Mar 1981	6367.765	0.3D/S	-.355	0.5D/S
8	18 Aug 1970	6368.313	0.4U/S	30 Mar 1981	6367.903	0.0	-.410	0.4D/S
9	18 Aug 1970	6368.362	0.8D/S	30 Mar 1981	6367.974	0.4D/S	-.388	0.4U/S
10	18 Aug 1970	6368.534	0.6U/S	30 Mar 1981	6368.117	0.3U/S	-.417	0.30D/S
11	18 Aug 1970	6368.649	0.2U/S	30 Mar 1981	6368.357	1.0D/S	-.292	1.2D/S
12	18 Aug 1970	6368.690	0.2U/S	30 Mar 1981	6368.400	0.1U/S	-.290	0.1D/S
13	18 Aug 1970	6368.688	0.8U/S	30 Mar 1981	6368.444	0.0	-.244	0.8D/S
14	18 Aug 1970	6369.106	0.7D/S	30 Mar 1981	6368.931	0.0	-.175	1.0U/S
15	18 Aug 1970	6369.776	0.7D/S	30 Mar 1981	6369.636	0.5U/S	-.140	1.20U/S

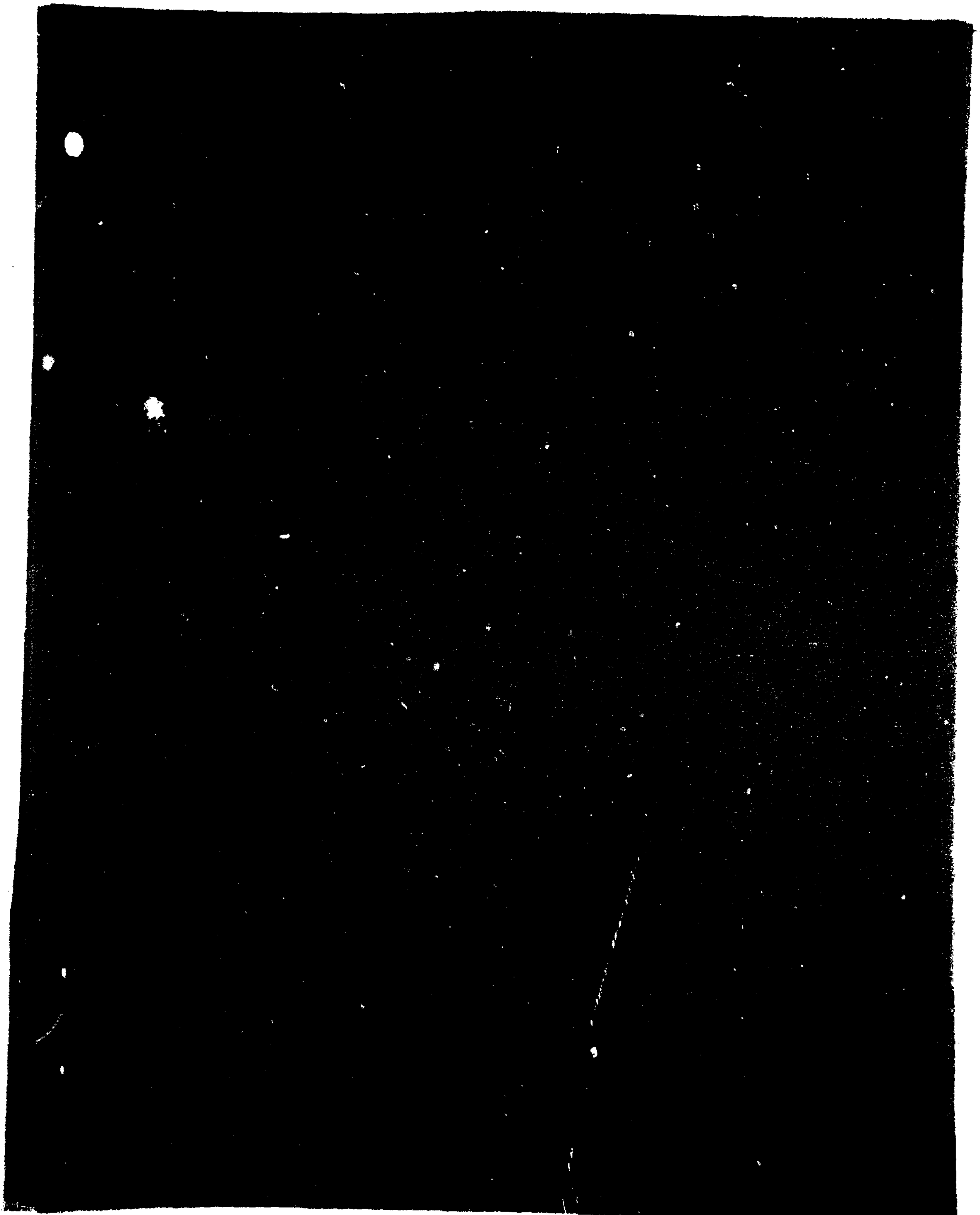
TABLE 6
ACCESS SHAFT JOINT MOVEMENT POINTS

POINT	DATE	INITIAL MEASUREMENT	DATE	MEASUREMENT	DATE	MEASUREMENT	SUM DIFFERENCE
V-1	8 Mar 1977	10.020	10 Jan 1980	10.005	21 Jan 1981	10.009	-.011
V-2	8 Mar 1977	10.144	10 Jan 1980	10.125	21 Jan 1981	10.018	-.126
V-3	8 Mar 1977	9.915	10 Jan 1980	9.981	21 Jan 1981	9.956	+.041

TABLE 7
OUTLET WORKS TUNNEL BOLT SETTLEMENT
POINTS AND JOINTS MOVEMENT POINTS

STATION	DATE	INITIAL ELEVATION	CURRENT DATE	ELEVATION	DIFFERENCE
25+90.50	Dec 1977	6062.776	Jan 1981	6062.709	-.067
24+95.50	Dec 1977	6063.226	Jan 1981	6063.224	-.002
23+92.50	Dec 1977	6063.764	Jan 1981	6063.761	-.003
22+95.50	Dec 1977	6064.334	Jan 1981	6064.337	+.003
21+93.50	Dec 1977	6064.747	Jan 1981	6064.942	-.005
20+94.50	Dec 1977	6065.459	Jan 1981	6065.956	-.003
19+96.50	Dec 1977	6066.003	Jan 1981	6066.005	+.002
18+99.50	Dec 1977	6066.482	Jan 1981	6066.477	-.005
17+99.50	Dec 1977	6067.182	Jan 1981	6067.185	+.003
16+94.50	Dec 1977	6067.714	Jan 1981	6067.720	+.006
15+96.50	Dec 1977	6068.266	Jan 1981	6068.260	-.006
14+96.50	Dec 1977	6068.858	Jan 1981	6068.860	+.002
13+94.50	Dec 1977	6069.422	Jan 1981	6069.410	-.012
12+96.50	Dec 1977	6069.891	Jan 1981	6069.879	-.012

POINT	DATE	STATION	INITIAL MEASUREMENT READING	INITIAL ELEVATION (ft)	DATE	CURRENT MEASUREMENT (in)	CURRENT ELEVATION (ft)	DIFFERENCE MEASUREMENT (in)	DIFFERENCE ELEVATION (ft)
JMP-1	8 Mar 1977	12+52.00	10.020	6070.121	21 Jan 1981	10.110	6070.122	+.090	+.001
		12+52.00		6070.156			6070.089		-.067
JMP-2	8 Mar 1977	17+26.50	9.627	6067.517	21 Jan 1981	9.612	6067.501	-.015	-.016
		17+26.50		6067.538			6067.520		-.018
JMP-3	8 Mar 1977	22+31.50	9.947	6064.779	21 Jan 1981	9.995	6064.749	+.048	-.030
		22+31.50		6064.790			6064.752		-.038
JMP-4	8 Mar 1977	26+05.50	9.815	6062.700	21 Jan 1981	9.995	6062.670	+.180	-.030
		26+05.50		6062.709			6062.689		-.020



ABIQUIU DAM AND RESERVOIR
RIO GRANDE BASIN, RIO CHAMA, NEW MEXICO
EMBANKMENT CRITERIA AND PERFORMANCE REPORT

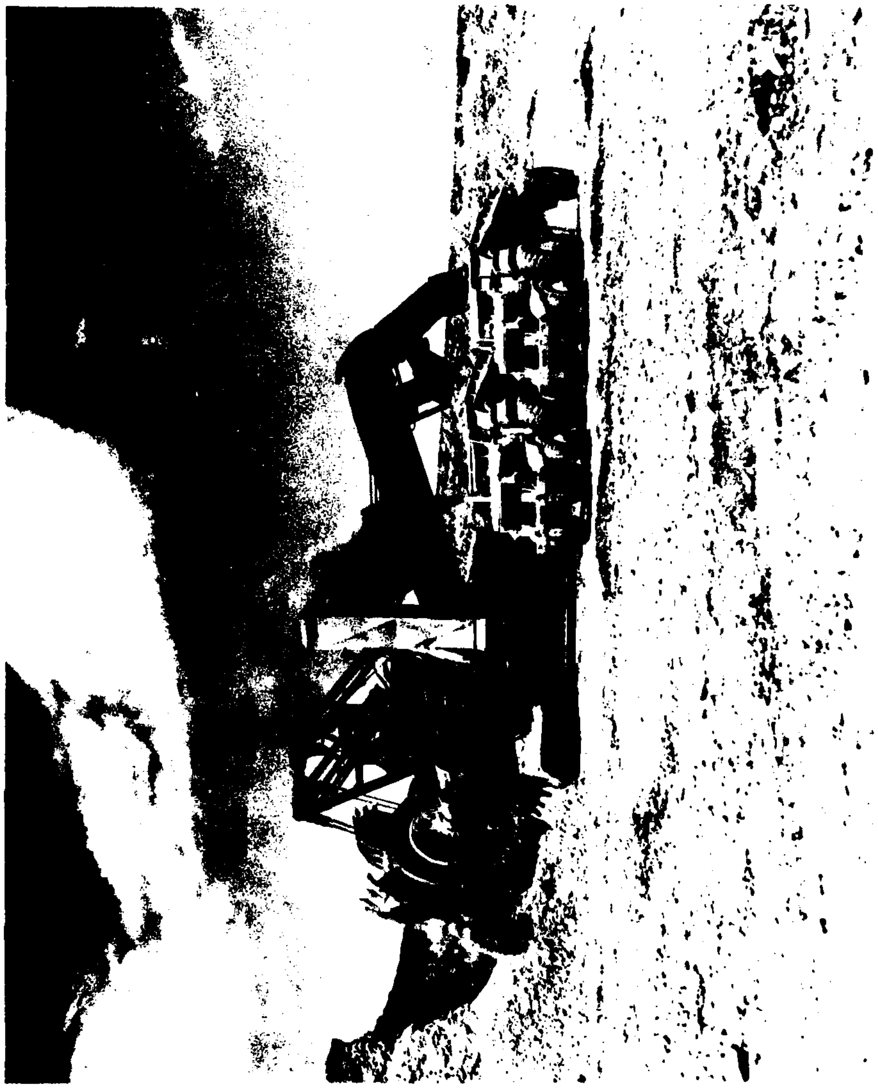


Photo 1

Wheel excavator loading borrow material into bottom dump hauling units.

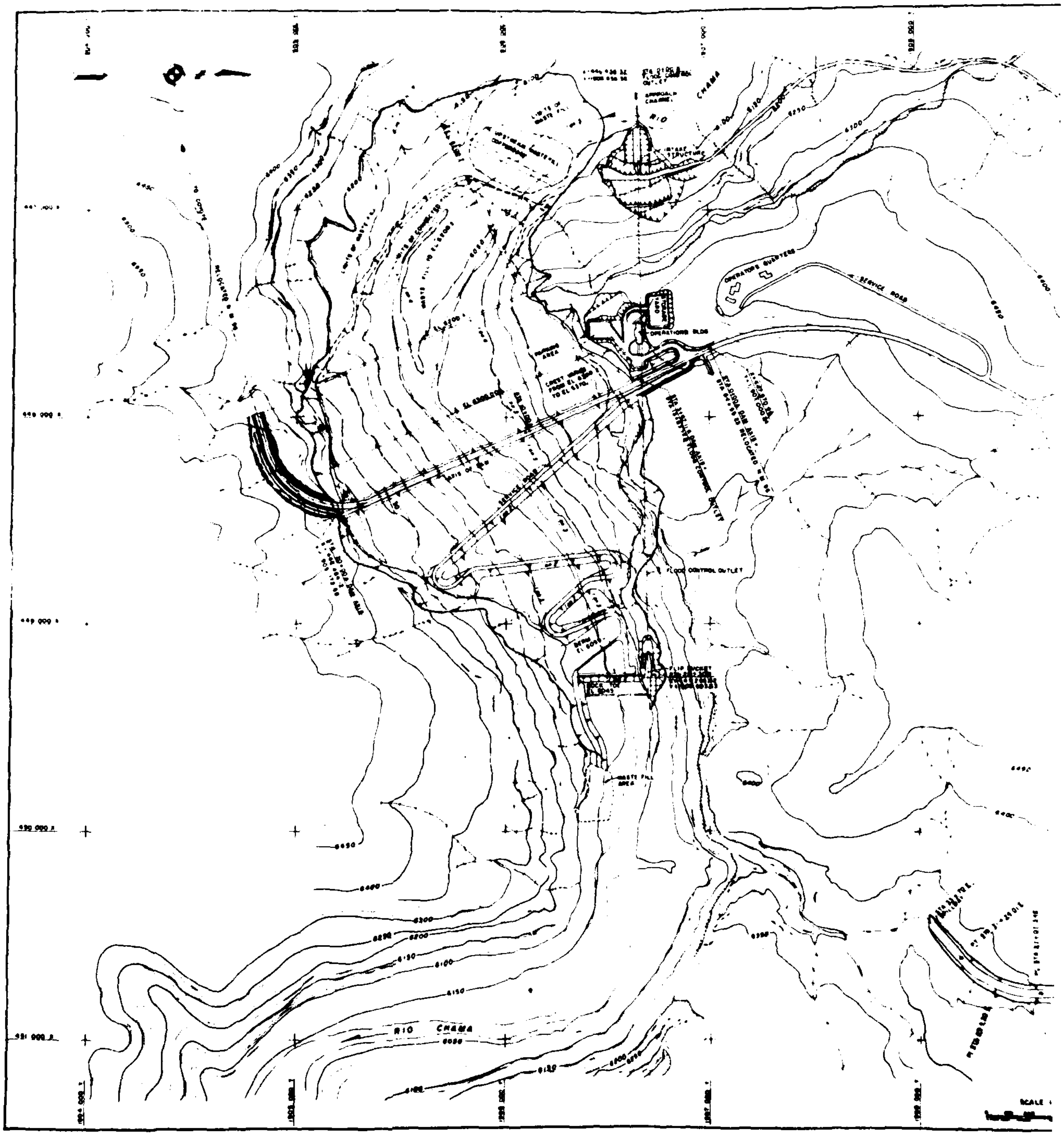
Photo 2

Upstream face of embankment. Conveyor belt from borrow area is in foreground.

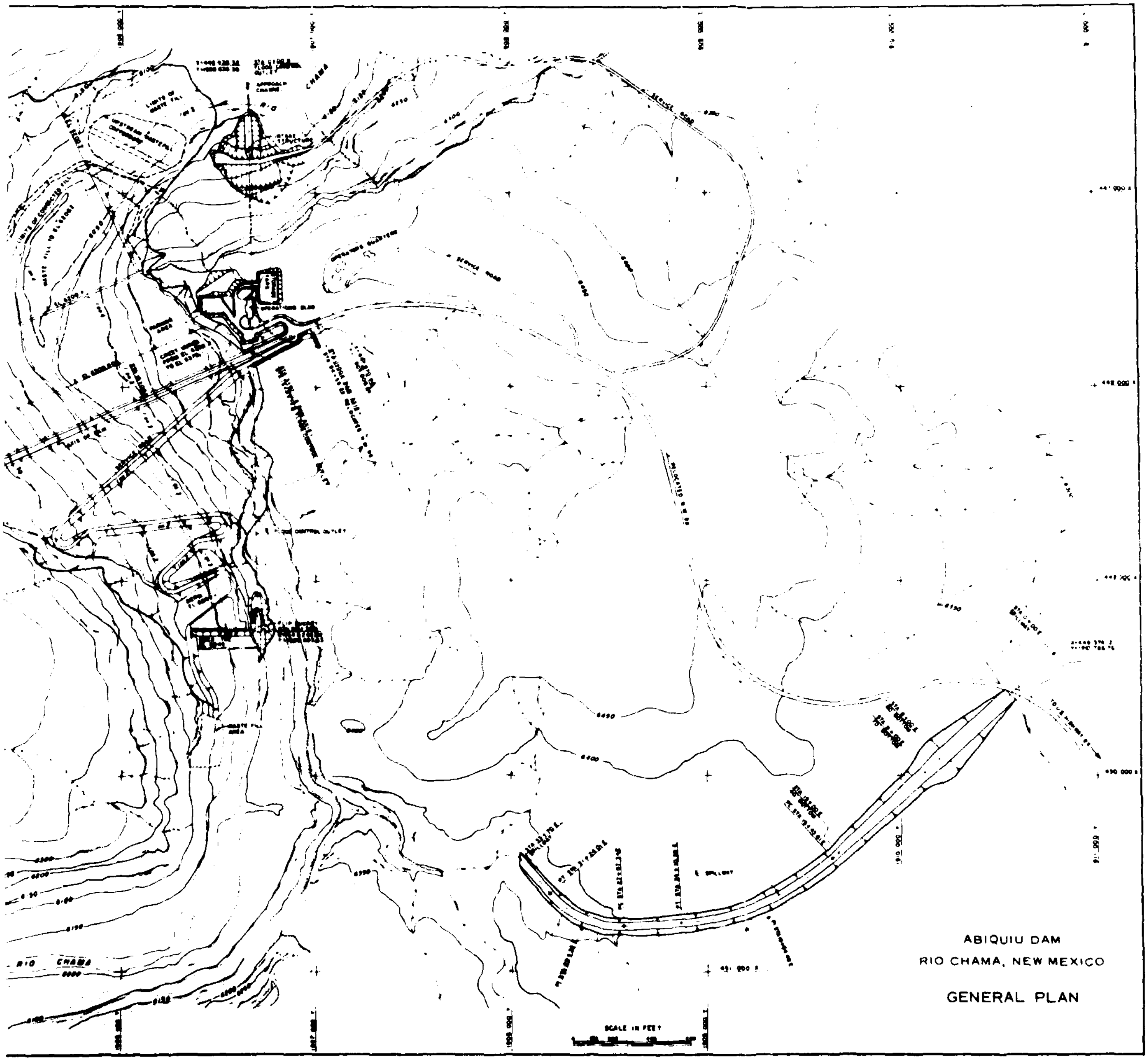
Photo 3

Scaling of left abutment.

Photo 4
Downstream face of embankment.

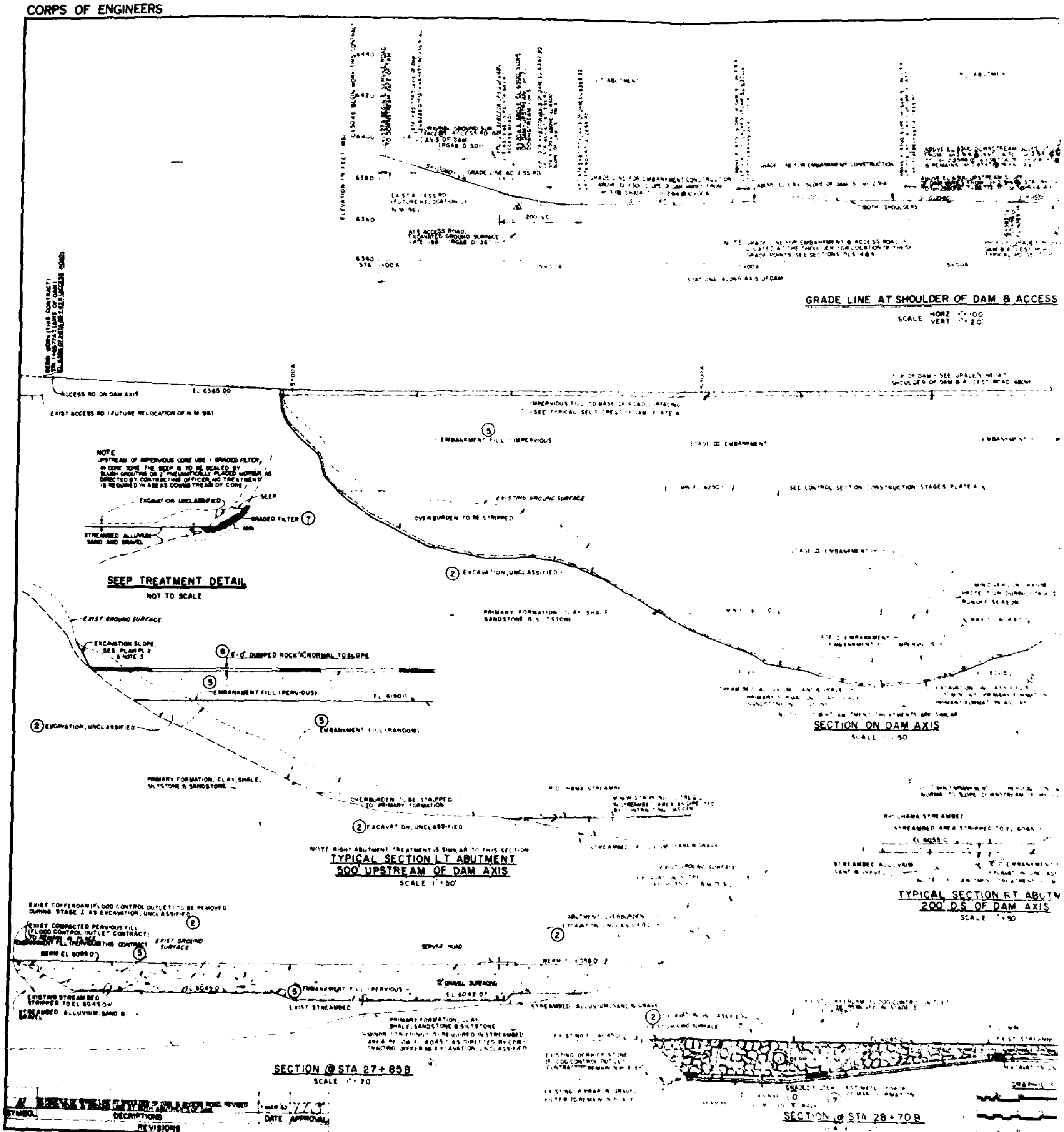


RIO CHAMA
OPERATORS QUARTERS
SERVICE ROAD
OPERATIONS BLDG
FLOOD CONTROL OUTLET
WASTE FILL AREA

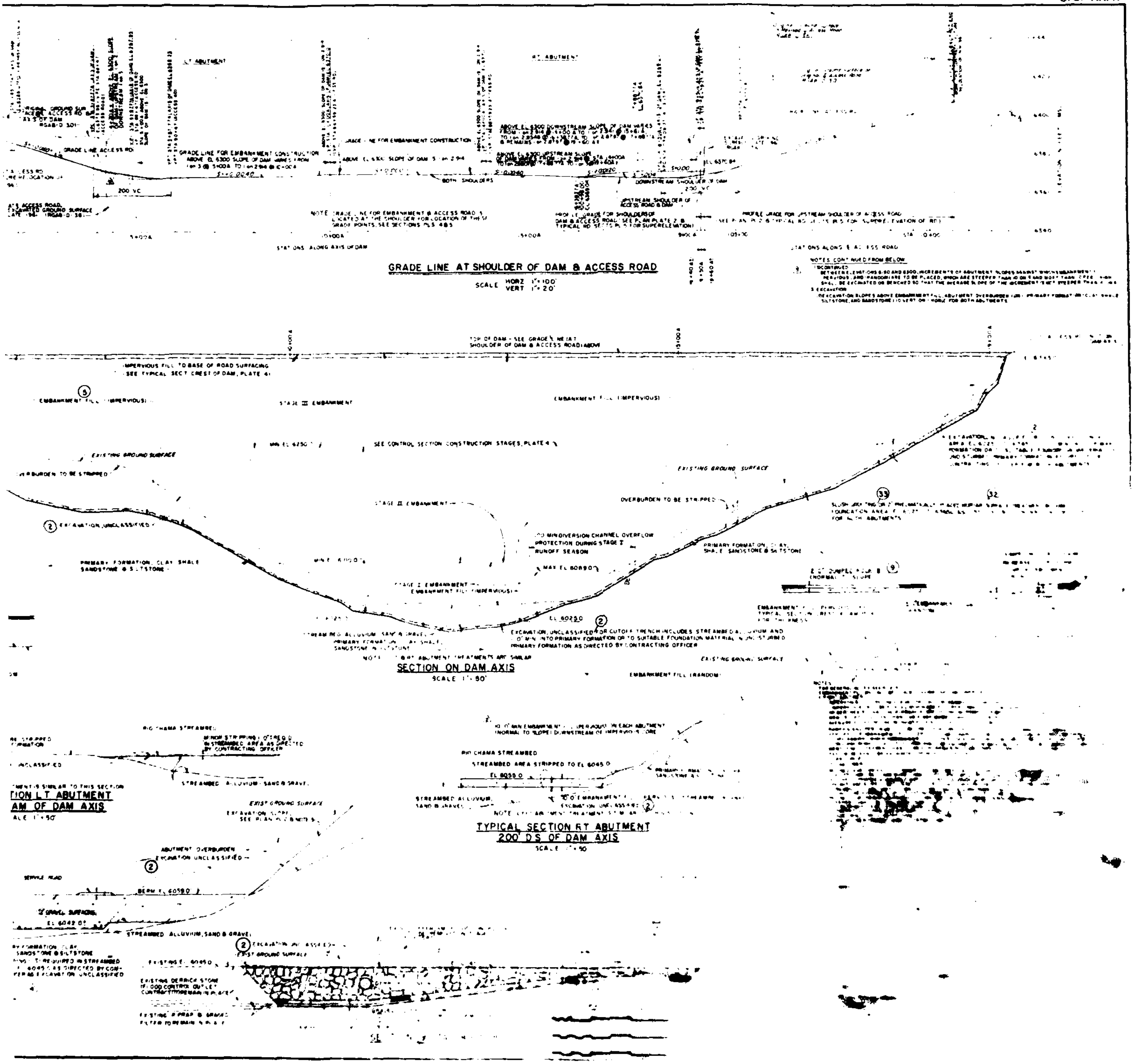


EMBANKMENT CRITERIA AND PERFORMANCE REPORT PLATE 1

CORPS OF ENGINEERS

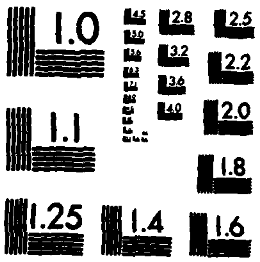


U.S. ARMY


LT ABUTMENT
RT ABUTMENT
GRADE LINE AT SHOULDER OF DAM & ACCESS ROAD
SCALE HORZ 1"=100' VERT 1"=20'
EMBANKMENT FILL (IMPERVIOUS)
STAGE III EMBANKMENT
STAGE II EMBANKMENT
EXISTING GROUND SURFACE
OVERBURDEN TO BE STRIPPED
PRIMARY FORMATION, CLAY SHALE SANDSTONE & SILTSTONE
EL 6025.0
SECTION ON DAM AXIS
SCALE 1"=50'
EMBANKMENT FILL (RANDOM)
RIO CHAMA STREAMBED
STREAMBED AREA STRIPPED TO EL 6045.0
TYPICAL SECTION RT ABUTMENT 200' D S OF DAM AXIS
SCALE 1"=50'
ABUTMENT OVERBURDEN
BERM EL 6059.0
STREAMBED ALLUVIUM, SAND & GRAVEL

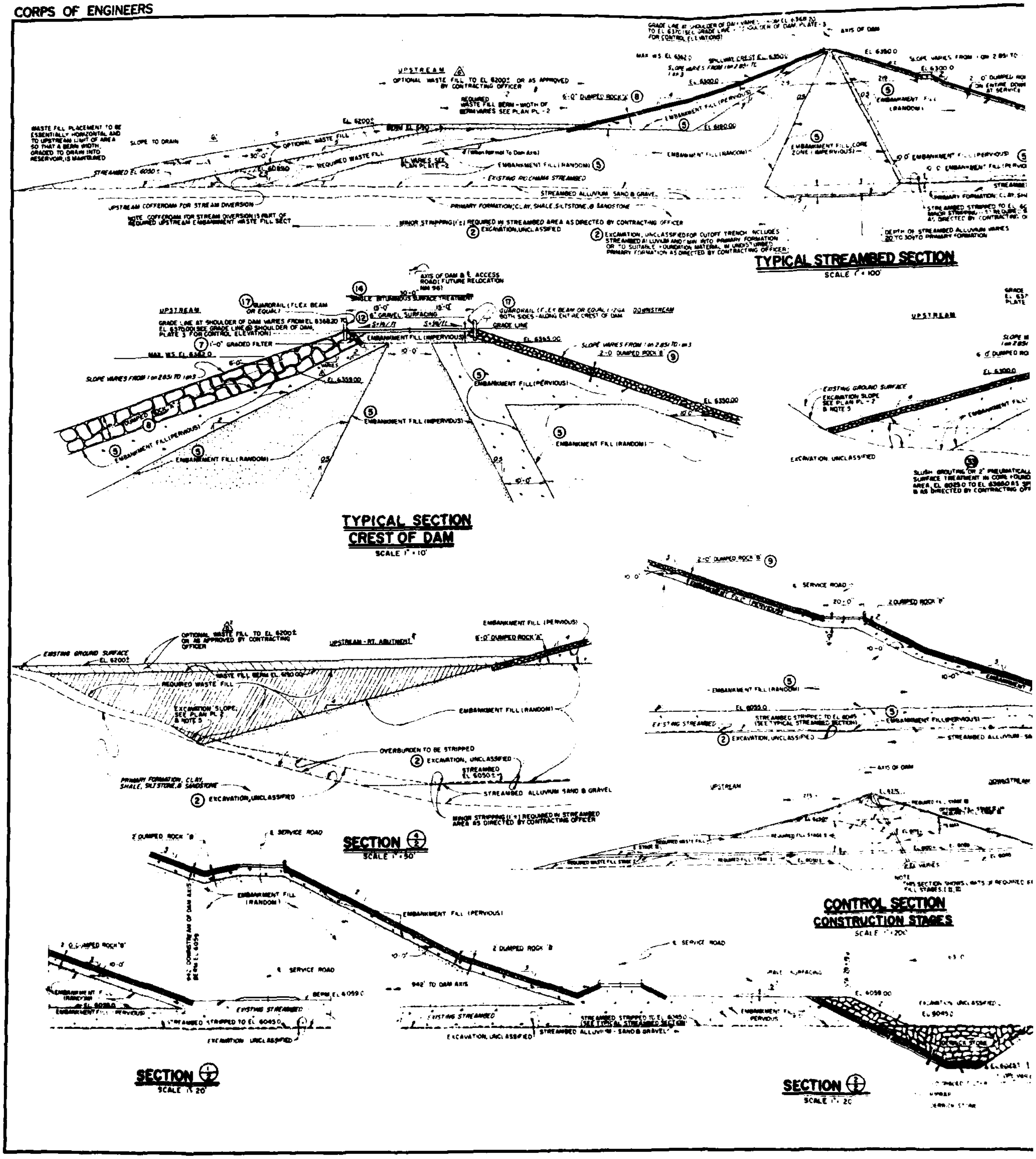
AD-A187 342 ABIQUIU DAM AND RESERVOIR RIO GRANDE BASIN RIO CHAMA NEW MEXICO EMBANKMENT CRITERIA AND PERFORMANCE REPORT (U) CORPS OF ENGINEERS TULSA OK TULSA DISTRICT APR 87 2/3

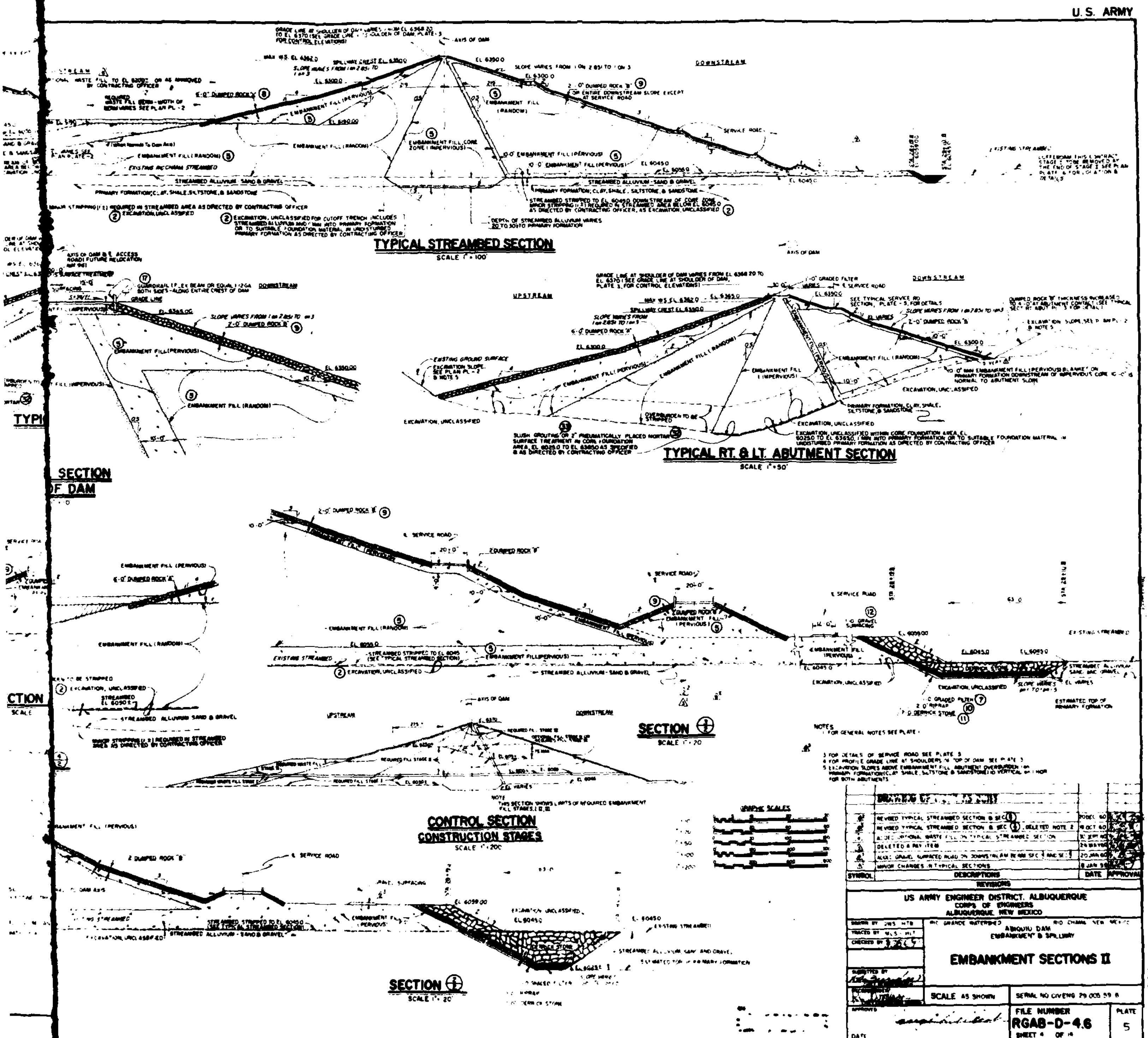
UNCLASSIFIED F/G 13/2 NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

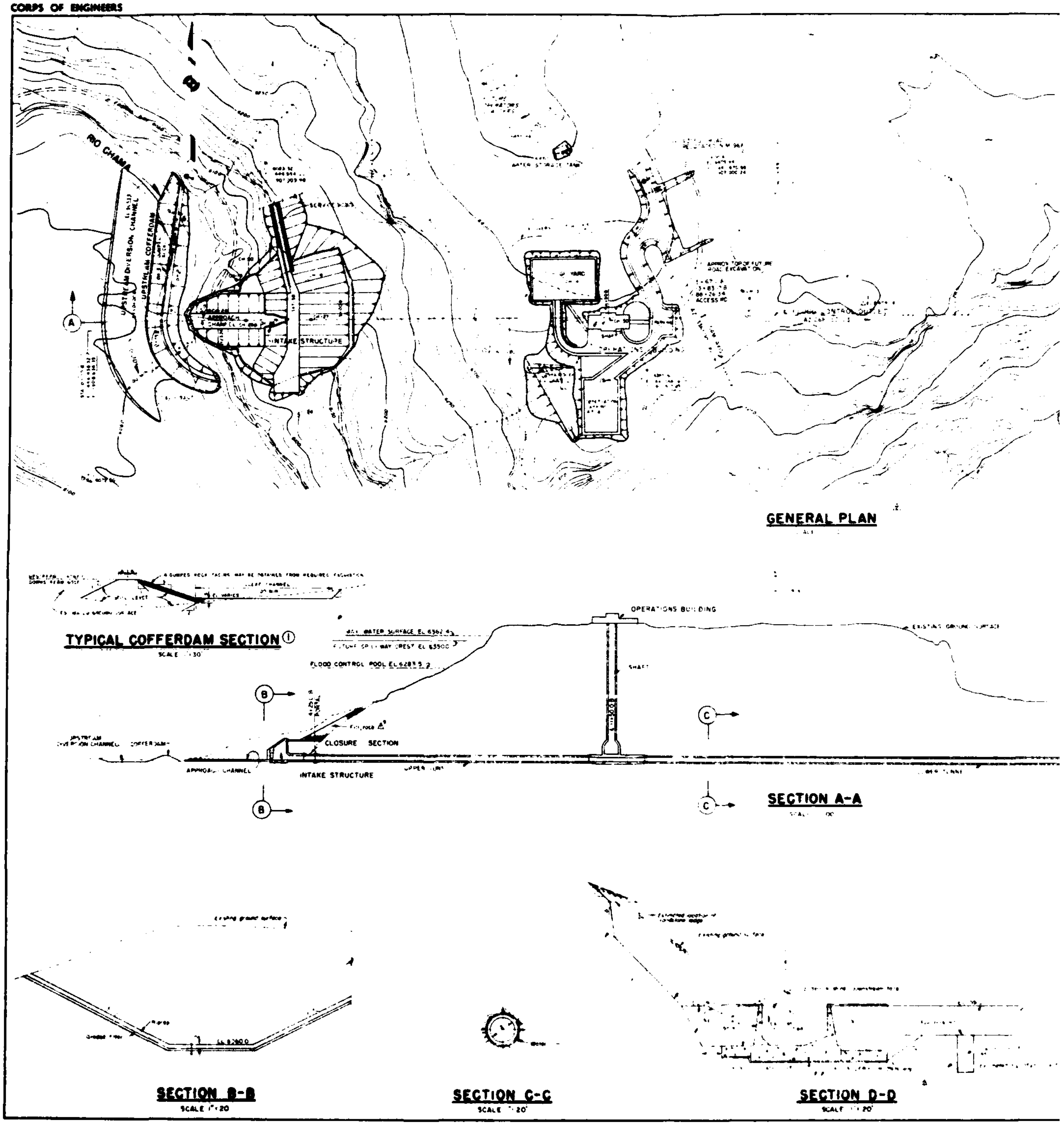
CORPS OF ENGINEERS

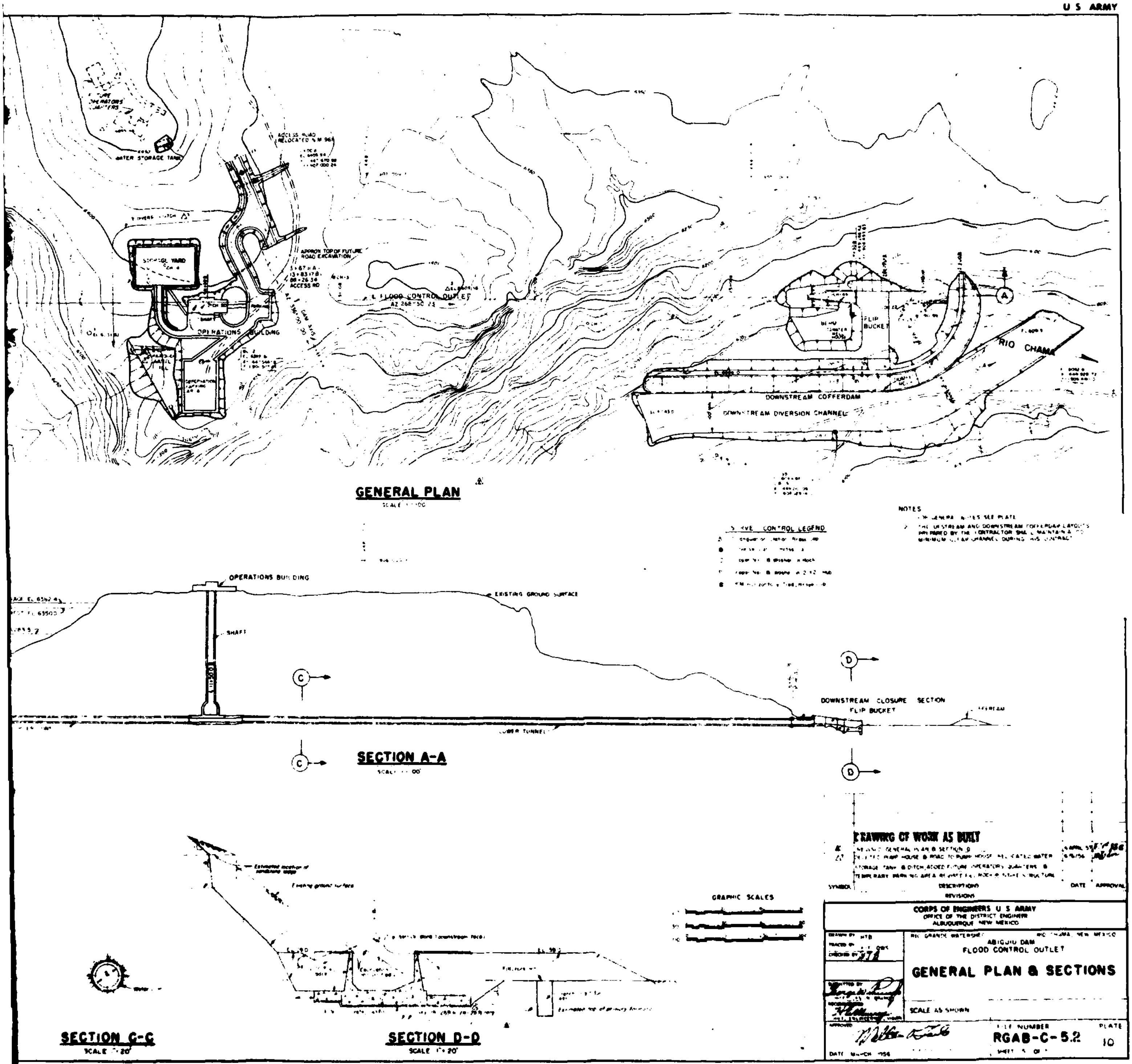




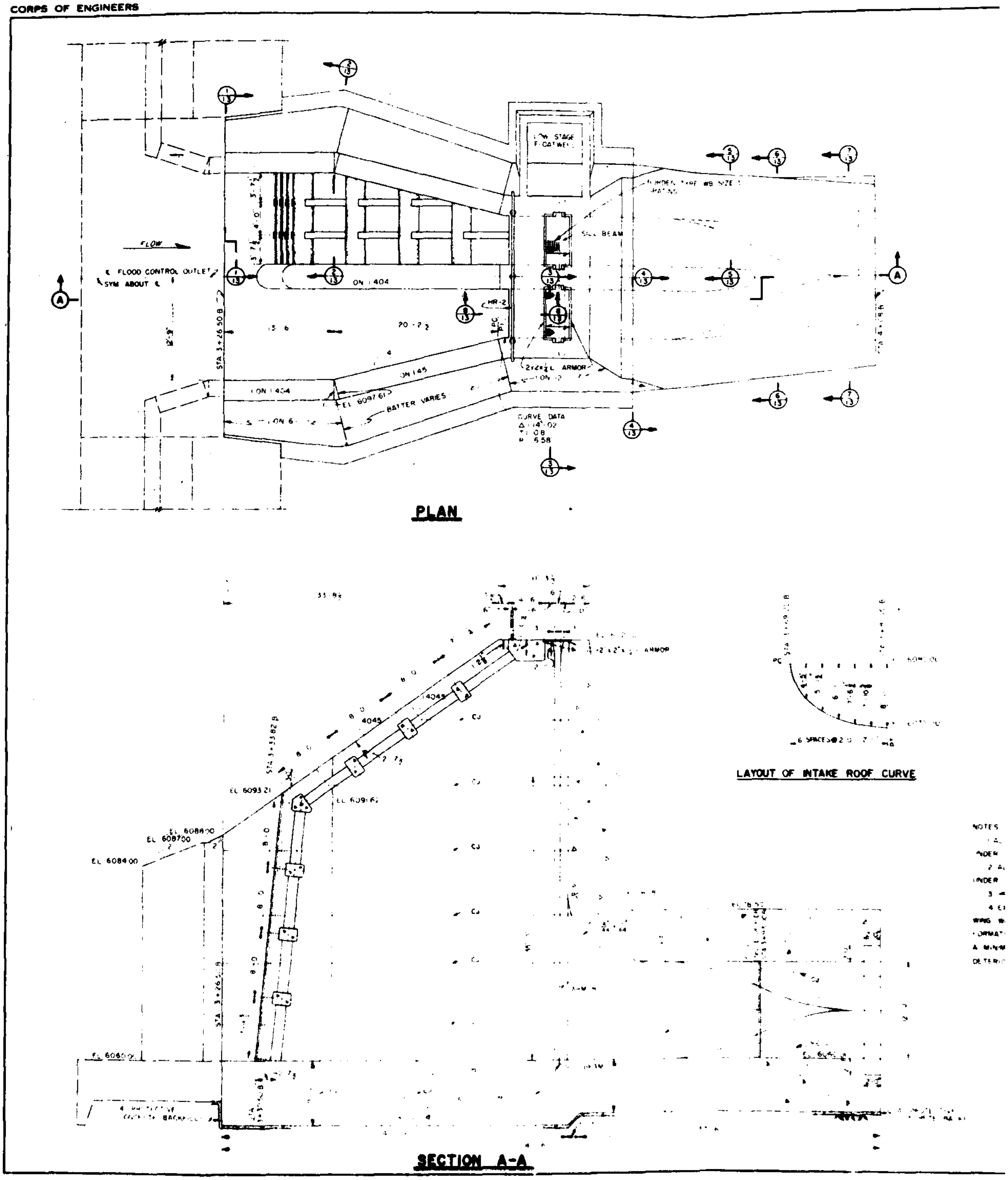
EMBANKMENT CRITERIA AND PERFORMANCE REPORT PLATE 3

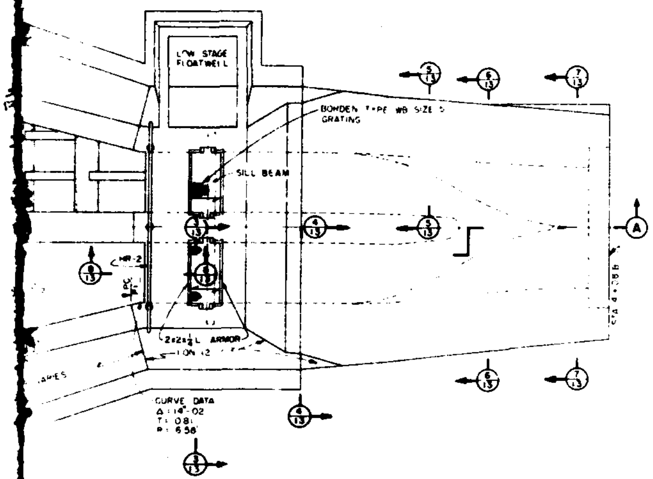
CORPS OF ENGINEERS



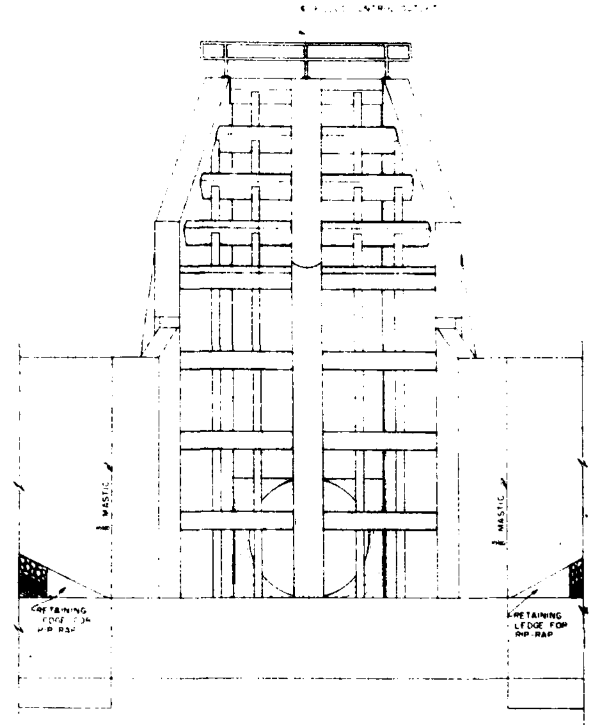

U S ARMY
GENERAL PLAN
WATER STORAGE TANK
ACCESS ROAD RELOCATED N.M. 96
STORAGE YARD
OPERATIONS BUILDING
APPROX TOP OF FUTURE ROAD EXCAVATION
ACCESS RD
FLOOD CONTROL OUTLET
FLIP BUCKET
RIO CHAMA
DOWNSTREAM COFFERDAM
DOWNSTREAM DIVERSION CHANNEL
NOTES
OPERATIONS BUILDING
EXISTING GROUND SURFACE
SHAFT
DOWNSTREAM CLOSURE SECTION
FLIP BUCKET
SECTION A-A
DRAWING OF WORK AS BUILT
SYMBOL
DESCRIPTION
DATE
APPROVAL
REVISIONS
GRAPHIC SCALES
CORPS OF ENGINEERS U S ARMY
OFFICE OF THE DISTRICT ENGINEER
ALBUQUERQUE NEW MEXICO
ABIQUIU DAM
FLOOD CONTROL OUTLET
GENERAL PLAN & SECTIONS
SCALE AS SHOWN
FILE NUMBER
RGAB-C-5.2
PLATE
10
SECTION C-C
SCALE 1"=20'
SECTION D-D
SCALE 1"=20'

CORPS OF ENGINEERS

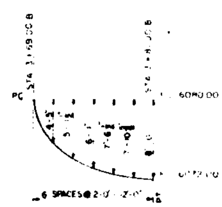




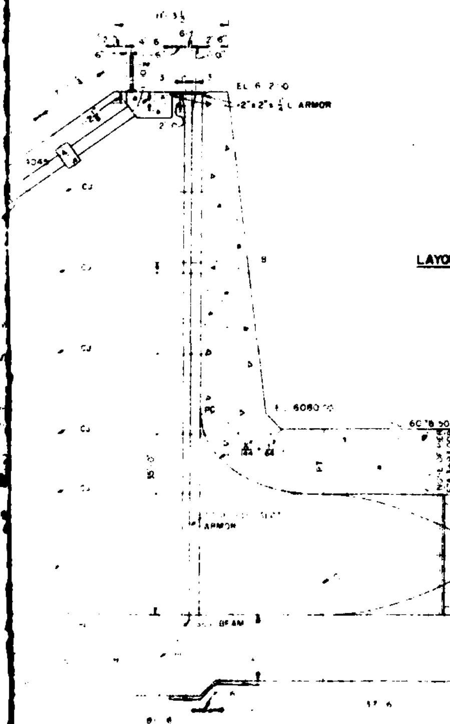
PLAN



ELEVATION LOOKING DOWNSTREAM



LAYOUT OF INTAKE ROOF CURVE



SECTION A-A

NOTES

1. ALL CONCRETE SHOWN ON THIS PLATE WILL BE PAID FOR UNDER PAY ITEM (14)
2. ALL METAL SHOWN ON THIS PLATE WILL BE PAID FOR UNDER PAY ITEM (29)
3. ⟵⟶ INDICATES DIRECTION OF GRATING BEARING BARS
4. EXCAVATION FOR THE INTAKE STRUCTURE, APPROACH SLAB, WING WALLS, AND CLOSURE SECTION SHALL BE TO PRIMARY FORMATION TO BE BACKFILLED WITH CONCRETE AS DIRECTED. A MINIMUM BACKFILL OF 4" TO PROTECT THE SHALE FROM DETERIORATION WILL BE REQUIRED AS SHOWN.

REFERENCE DRAWINGS

1. FOR GENERAL NOTES, PLATE
2. FOR ASSEMBLY AND GENERAL STRUCTURAL NOTES, PLATE 6
3. FOR HANDRAIL DETAILS, PLATE 48
4. FOR TRANSITION LAYOUT, PLATE
5. FOR REINFORCEMENT DETAILS, PLATES 14 & 16
6. FOR EXCAVATION AND GRADING PLANS, PLATE 7
7. FOR STOPLOGS AND STOPLOG ARMOR, PLATE 48
8. FOR HANDRAIL DETAILS, PLATE 48
9. FOR ARTICULATION JOINT DETAILS, PLATE 6
10. FOR APPROACH SLAB AND WING WALL DETAILS, PLATES 8 & 9
11. FOR FLOATWELL DETAILS, PLATES 9 44

GRAPHIC SCALE

CORPS OF ENGINEERS U S ARMY
OFFICE OF THE DISTRICT ENGINEER
ALBUQUERQUE NEW MEXICO

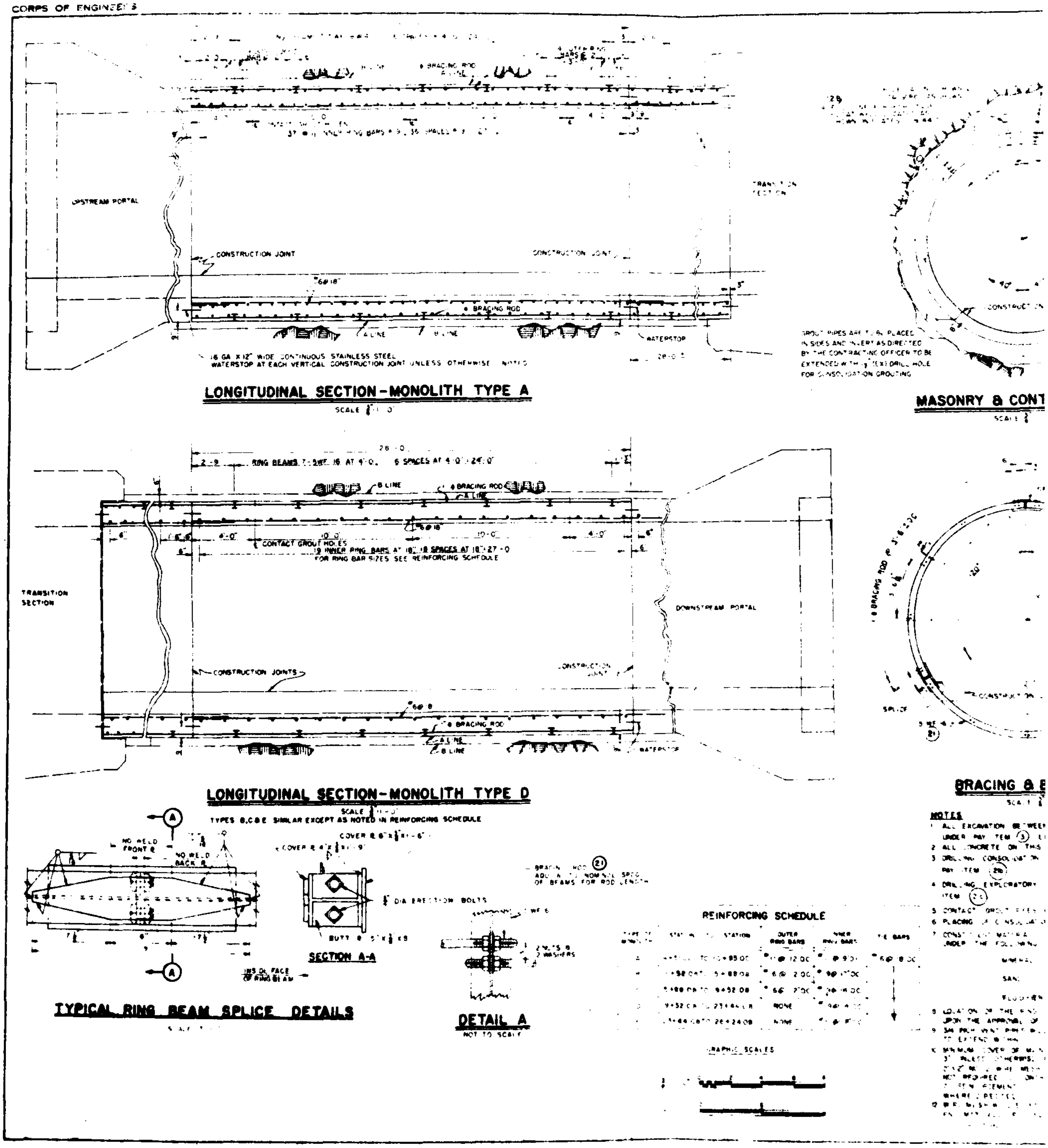
RIO GRANDE WATERSHED — RIO CHAMA NEW MEXICO
ABIQUIU DAM
FLOOD CONTROL OUTLET
INTAKE STRUCTURE
PLAN, SECTION, & ELEVATION

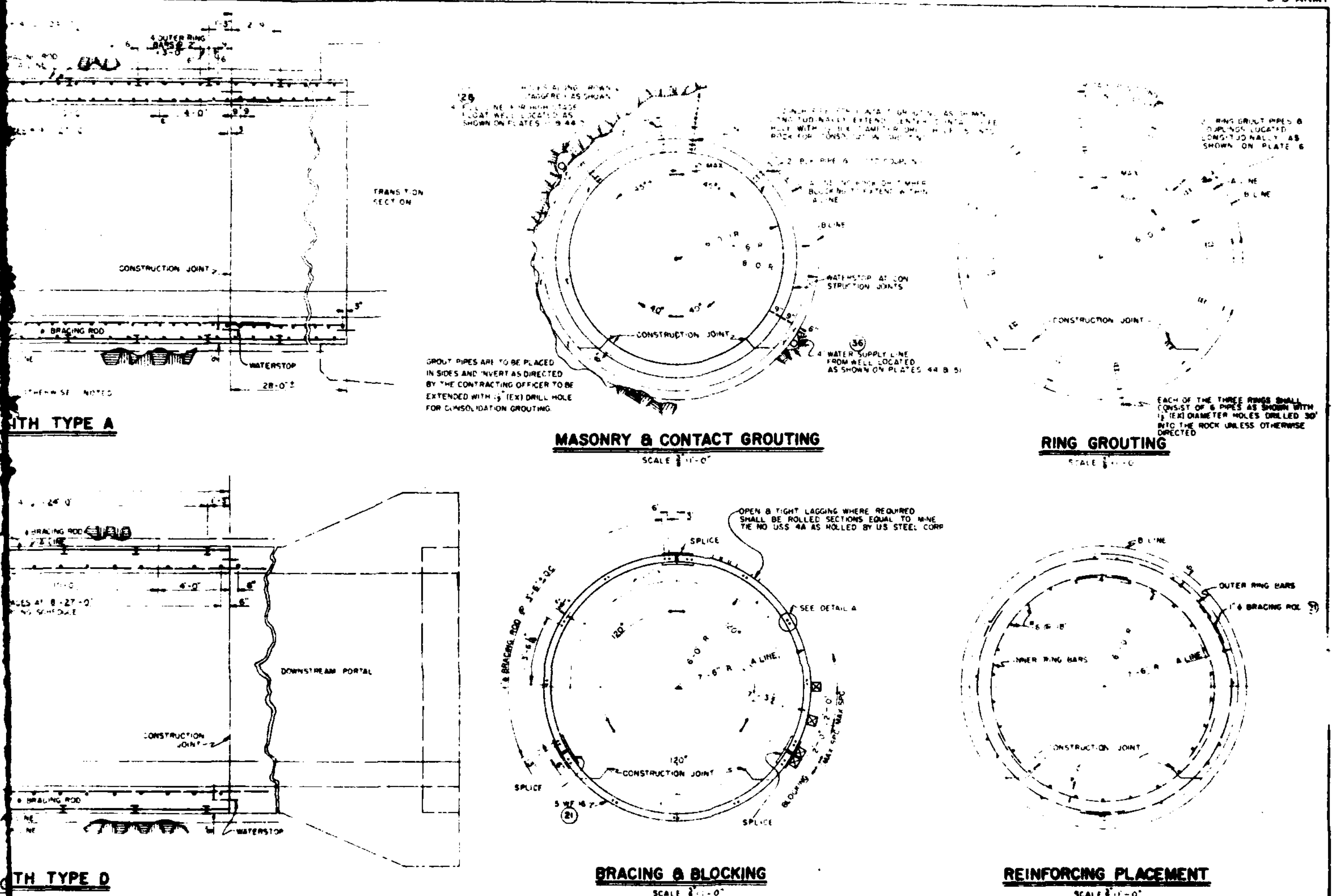
SCALE ¼" = 1'-0"

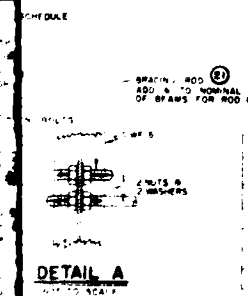
FILE NUMBER RGAB-C-12 — PLATE 11

U S ARMY

CORPS OF ENGINEERS







REINFORCING SCHEDULE

TYPE OF MONOLITH	STATION TO STATION	OUTER RING BARS	INNER RING BARS	TIE BARS
A	4+51.00 TO 10+95.00	#11 @ 12" OC	#11 @ 9" OC	#6 @ 18" OC
B	12+38.08 TO 15+88.08	#6 @ 12" OC	#9 @ 12" OC	
C	15+88.08 TO 19+52.08	#6 @ 12" OC	#9 @ 18" OC	
D	19+52.08 TO 23+44.08	NONE	#9 @ 18" OC	
F	23+44.08 TO 26+24.08	NONE	# @ 18" OC	

GRAPHIC SCALES

NOTES

1. ALL EXCAVATION BETWEEN STA 4+25B & STA 26+60B WILL BE PAID FOR UNDER PAY ITEM (3) EXCEPT THAT PAID FOR AS SHAFT EXCAVATION
2. ALL CONCRETE ON THIS PLATE WILL BE PAID FOR UNDER PAY ITEM (15)
3. DRILLING CONSOLIDATION AND RING GROUT HOLES WILL BE PAID FOR UNDER PAY ITEM (21b)
4. DRILLING EXPLORATORY HOLES AS DIRECTED WILL BE PAID FOR UNDER PAY ITEM (21c)
5. CONTACT GROUT PIPES WILL BE PAID FOR UNDER PAY ITEM (29)
6. PLACING OF CONSOLIDATION GROUT WILL BE PAID FOR UNDER PAY ITEM (21a)
7. CONSTITUENT MATERIALS FOR CONSOLIDATION GROUTING WILL BE PAID FOR UNDER THE FOLLOWING PAY ITEMS

   MINERAL FILLER (21d)
   SAND (21e)
   FLUIDIFIER (21f)

8. LOCATION OF THE RING BEAM SPLICES MAY BE VARIED FROM THAT SHOWN UPON THE APPROVAL OF THE CONTRACTING OFFICER
9. SIX INCH VENT PIPES WILL BE PLACED AS DIRECTED BY CONTRACTING OFFICER TO EXTEND WITHIN [illegible] OF THE ROCK AT THE POINTS OF HIGHEST OVERBREAK
10. MINIMUM COVER OF MAIN REINFORCEMENT SHOWN ON THIS PLATE SHALL BE 3" UNLESS OTHERWISE NOTED
11. 2"x2" NO 12 WIRE MESH WILL BE USED AS DIRECTED WHERE TIGHT LAGGING IS NOT REQUIRED TO CONTROL THE SIZE [illegible] AND TO SERVE AS REINFORCEMENT [illegible] WHERE DIRECTED
12. WIRE MESH WILL BE PAID FOR UNDER PAY ITEM [illegible]
13. PNEUMATICALLY PLACED MORTAR WILL BE PAID FOR UNDER PAY ITEM [illegible]

REFERENCE DWGS
1. FOR GENERAL NOTES PLATE 1
2. FOR ASSEMBLY AND GENERAL STRUCTURAL NOTES, PLATE 6
3. FOR TYPICAL GROUT PIPE DETAILS, PLATE 26
4. FOR TUNNEL PORTAL DETAILS PLATES 18 & 19

RIO GRANDE WATERSHED — RIO CHAMA, N.M.

ABIQUIU DAM

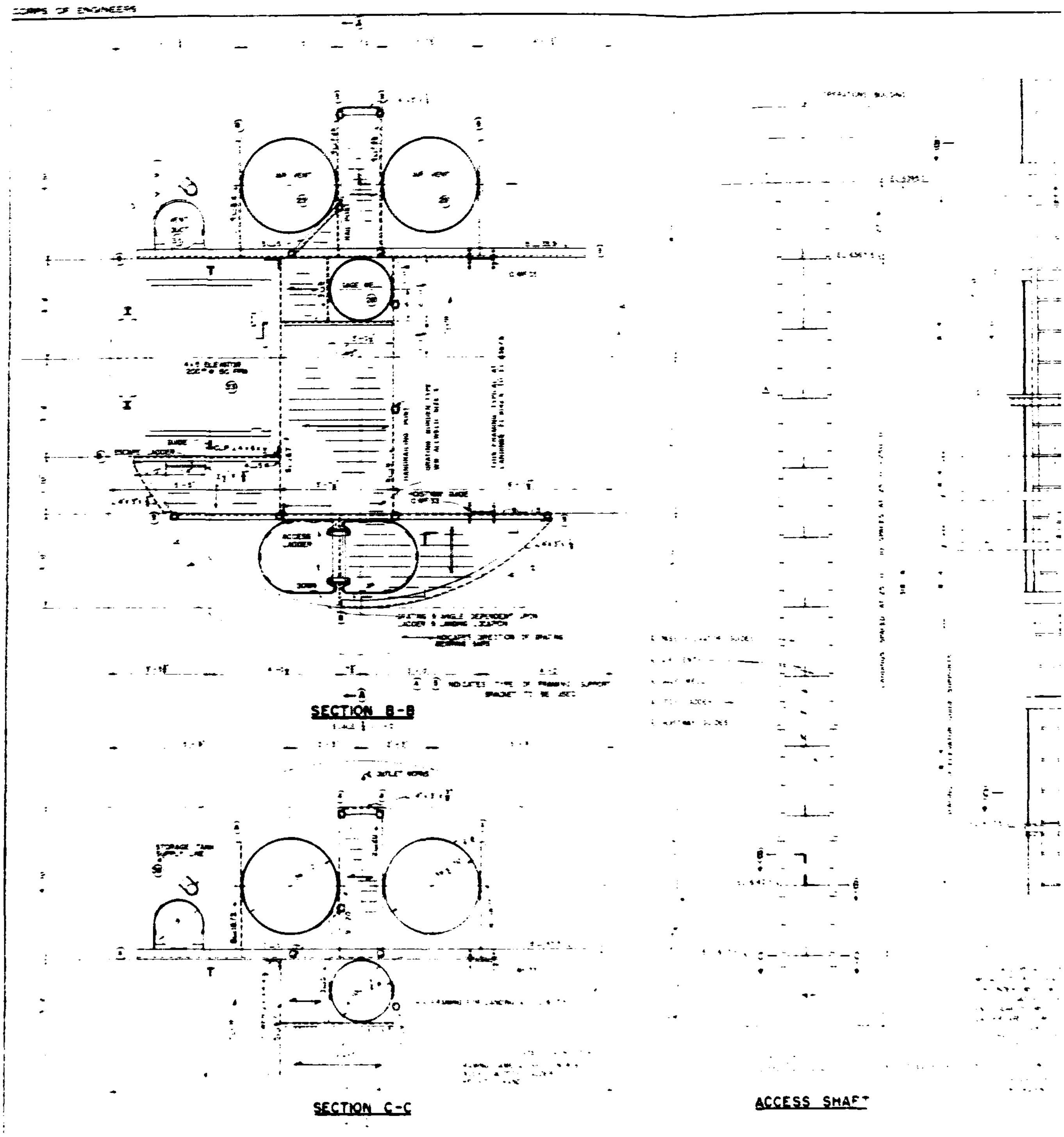
TUNNEL DETAILS

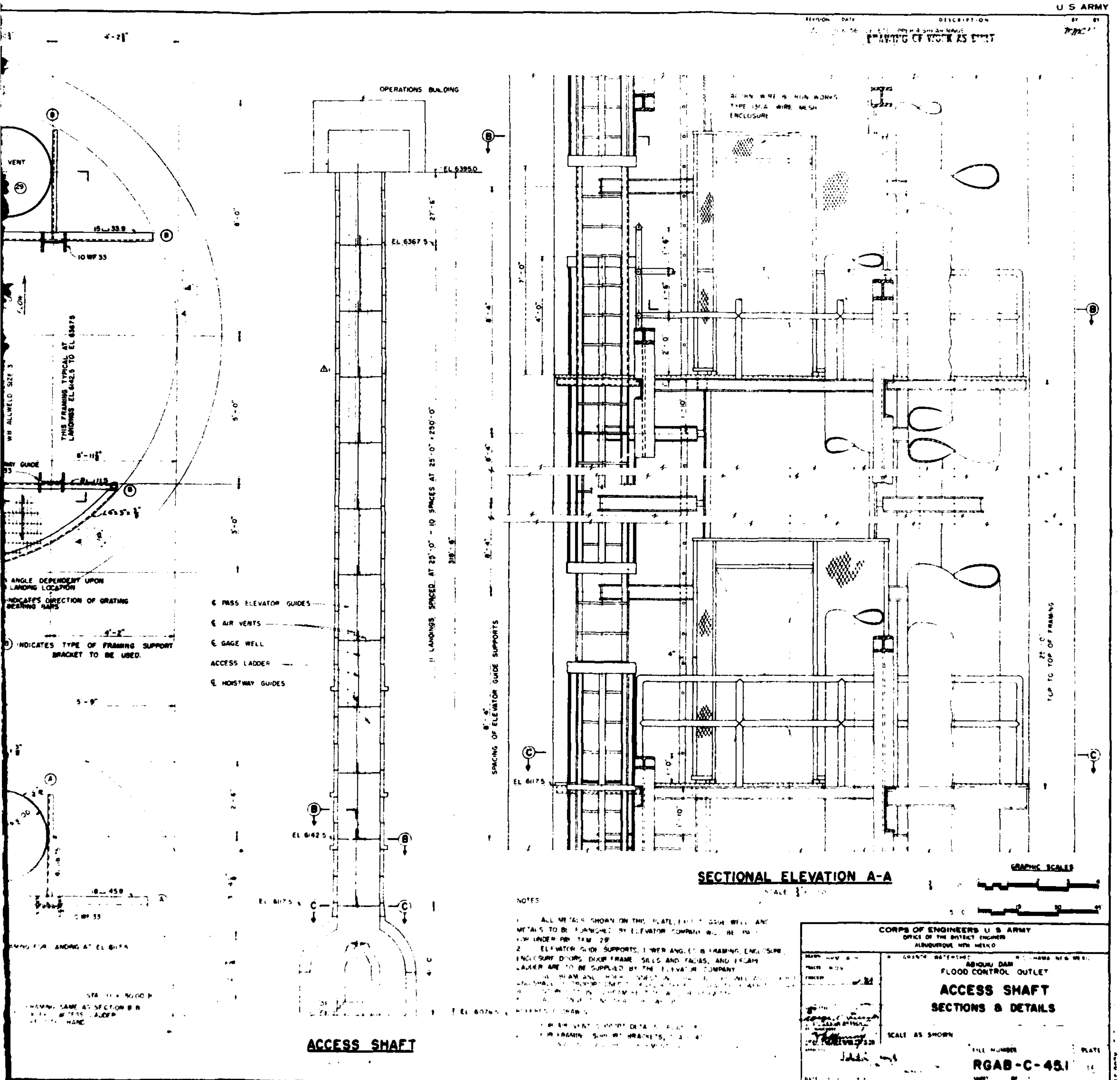
SCALE AS SHOWN

ALBUQUERQUE DISTRICT, ALBUQUERQUE, N.M.

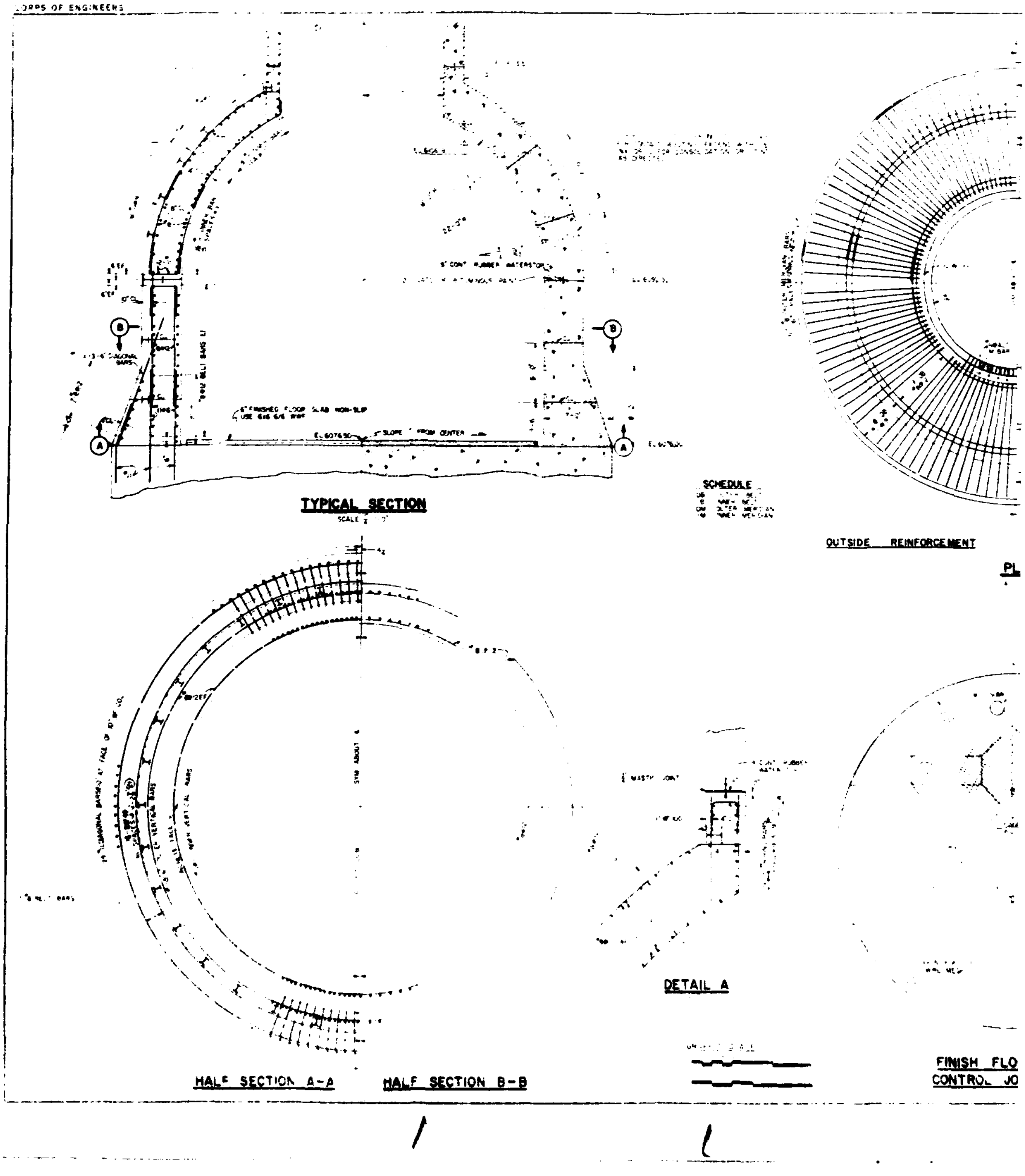
TO ACCOMPANY DESIGN MEMORANDUM ON FLOOD CONTROL OUTLET DATED JUNE 1956

FILE NO RG-CH-G-19/25

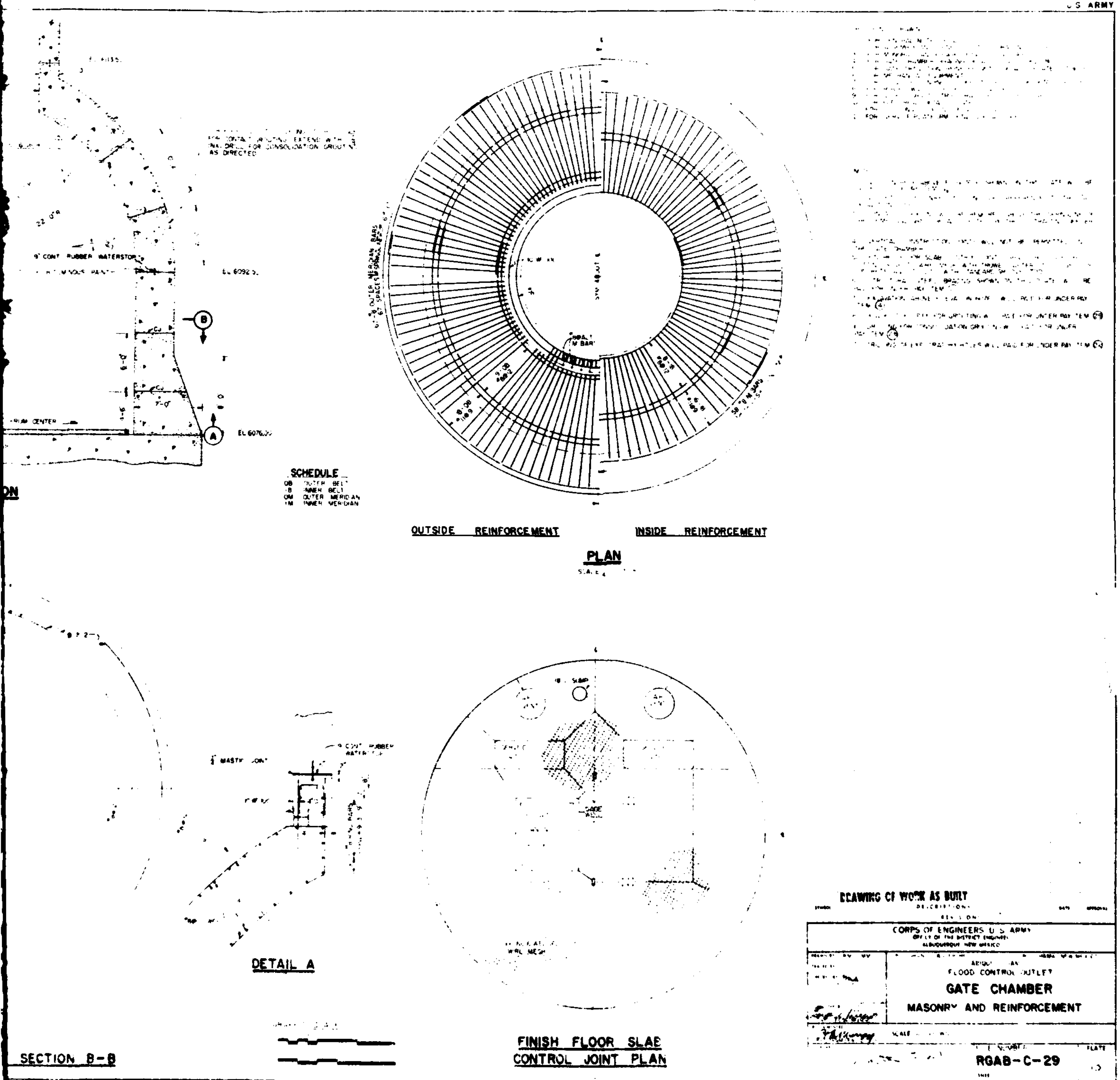

CORPS OF ENGINEERS
ACCESS LADDER
SECTION B-B
SECTION C-C
ACCESS SHAFT



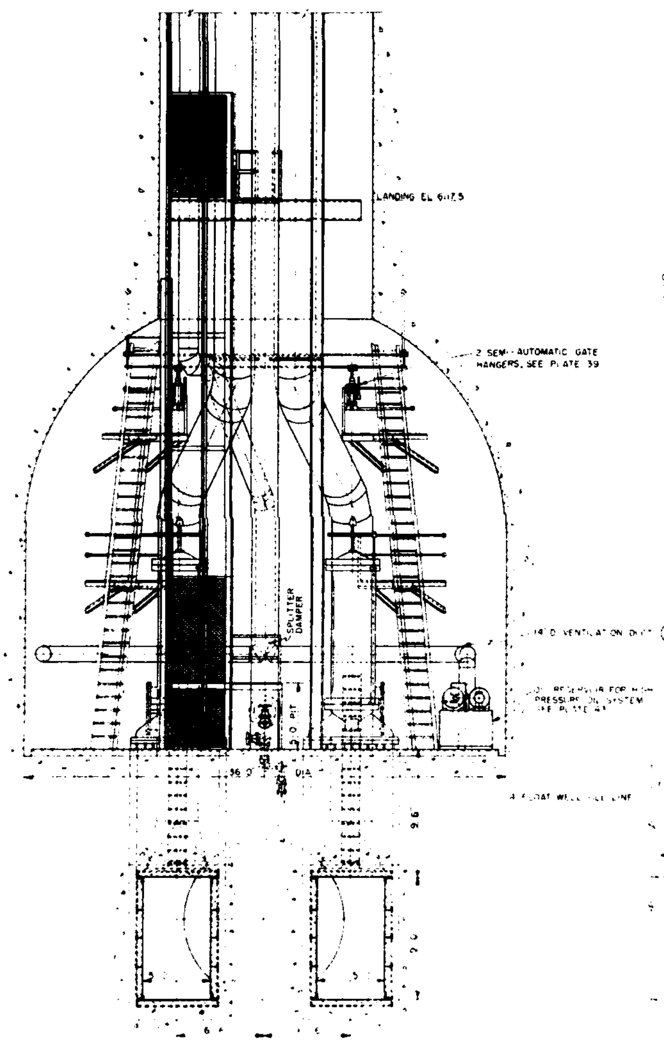
EMBANKMENT CRITERIA AND PERFORMANCE REPORT PLATE 7



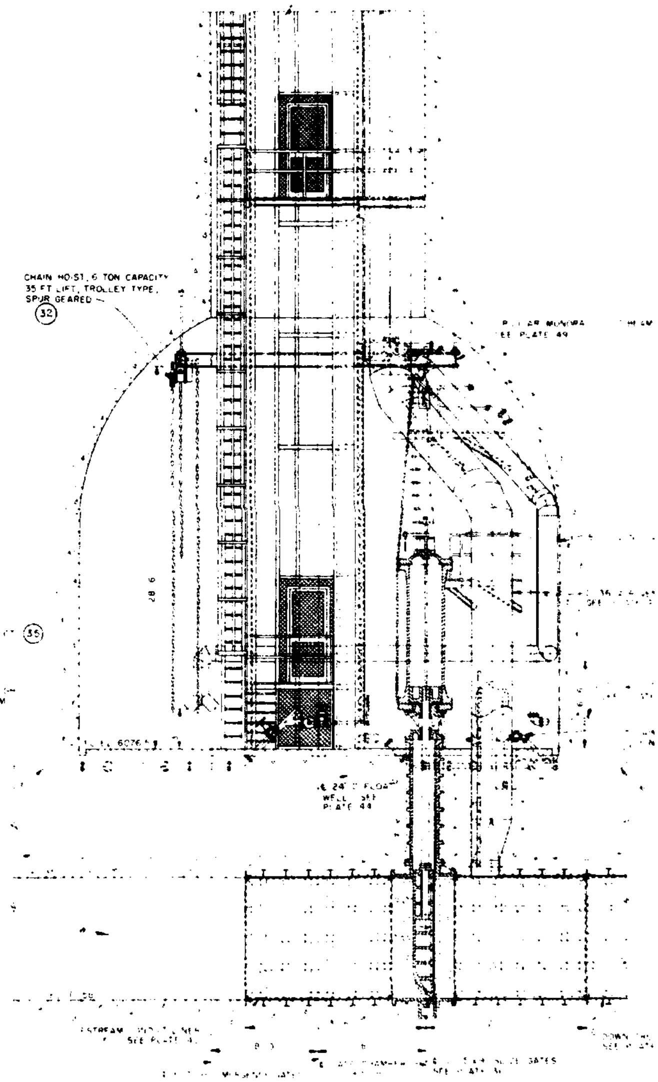
CORPS OF ENGINEERS
TYPICAL SECTION
SCHEDULE
OUTSIDE REINFORCEMENT
DETAIL A
HALF SECTION A-A
HALF SECTION B-B
FINISH FLO
CONTROL JO


U.S. ARMY
SCHEDULE
OB OUTER BELT
IB INNER BELT
OM OUTER MERIDIAN
IM INNER MERIDIAN
9" CONT. RUBBER WATERSTOP
OUTSIDE REINFORCEMENT
INSIDE REINFORCEMENT
PLAN
DETAIL A
SECTION B-B
FINISH FLOOR SLAB
CONTROL JOINT PLAN
DRAWING OF WORK AS BUILT
CORPS OF ENGINEERS U.S. ARMY
FLOOD CONTROL OUTLET
GATE CHAMBER
MASONRY AND REINFORCEMENT
RGAB-C-29

CORPS OF ENGINEERS

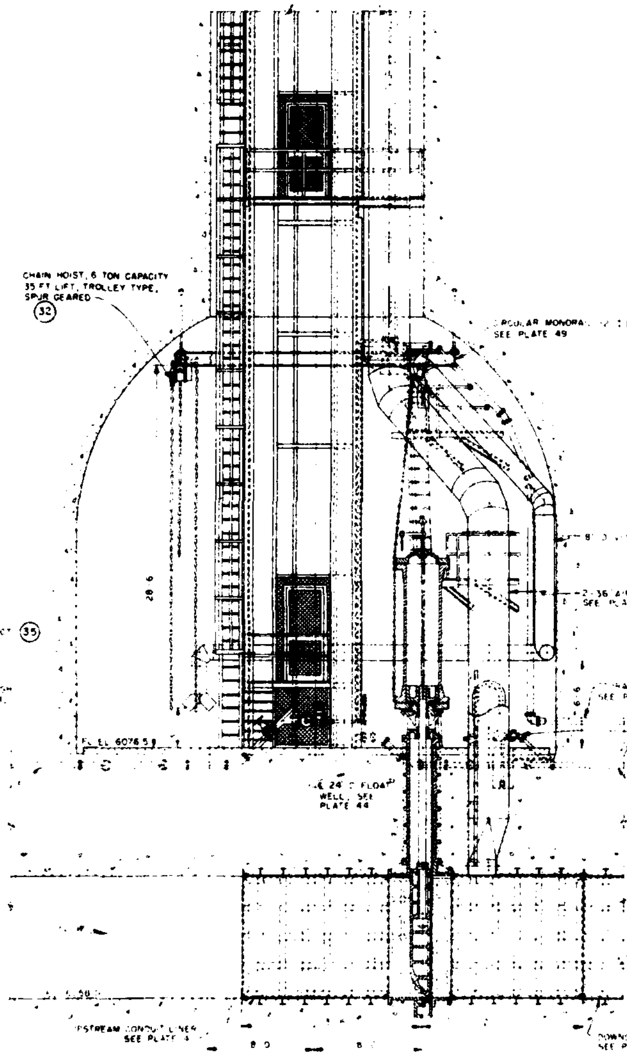


SECTION A-A

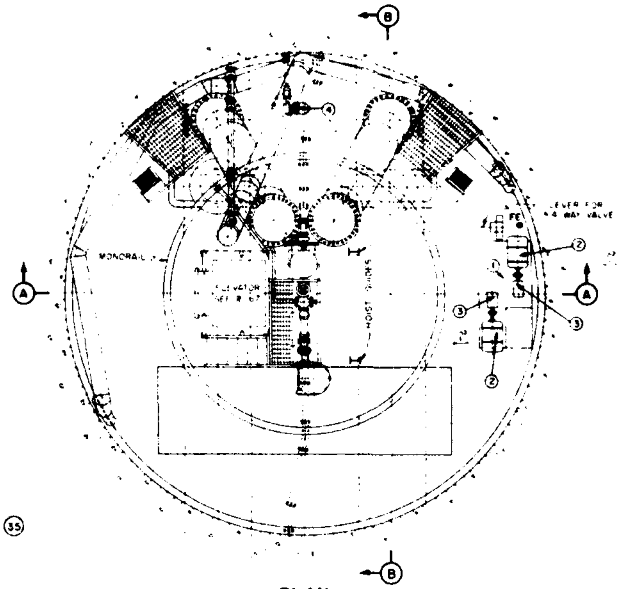


SECTION B-B

US ARMY



SECTION B-B



PLAN

	INSTALLED EQUIPMENT			
ITEM	NAME	SIZE	MODEL	SERIAL NO
1	RUCKER HYDRAULIC POWER UNIT		56-1063	DU 949
2	G E TRICLAD PUMP MOTOR	30 HP	5K1405-PL1	TP 263014
2	G E TRICLAD PUMP MOTOR	30 HP	5K1405-PL1	TP 263015
3	DUDCO HYDRAULIC PUMP		PFB-40-CW-M-LR	KK 2328
3	DUDCO HYDRAULIC PUMP		PFB-40-M-RL	2217
4	APCO TURBINE PUMP	18 GPM	GGA-C480625-BF	
4	APCO TURBINE PUMP MOTOR		P184M4A7	D 58
32	OHIO SPUR GEAR MONORAIL HOIST	6 TON	20-5	

DRAWINGS OF WORK AS BUILT

DESCRIPTIONS

REVISIONS

CORPS OF ENGINEERS U S ARMY
OFFICE OF THE DISTRICT ENGINEER
ALBUQUERQUE NEW MEXICO

ABIQUIU DAM
FLOOD CONTROL OUTLET

GATE CHAMBER

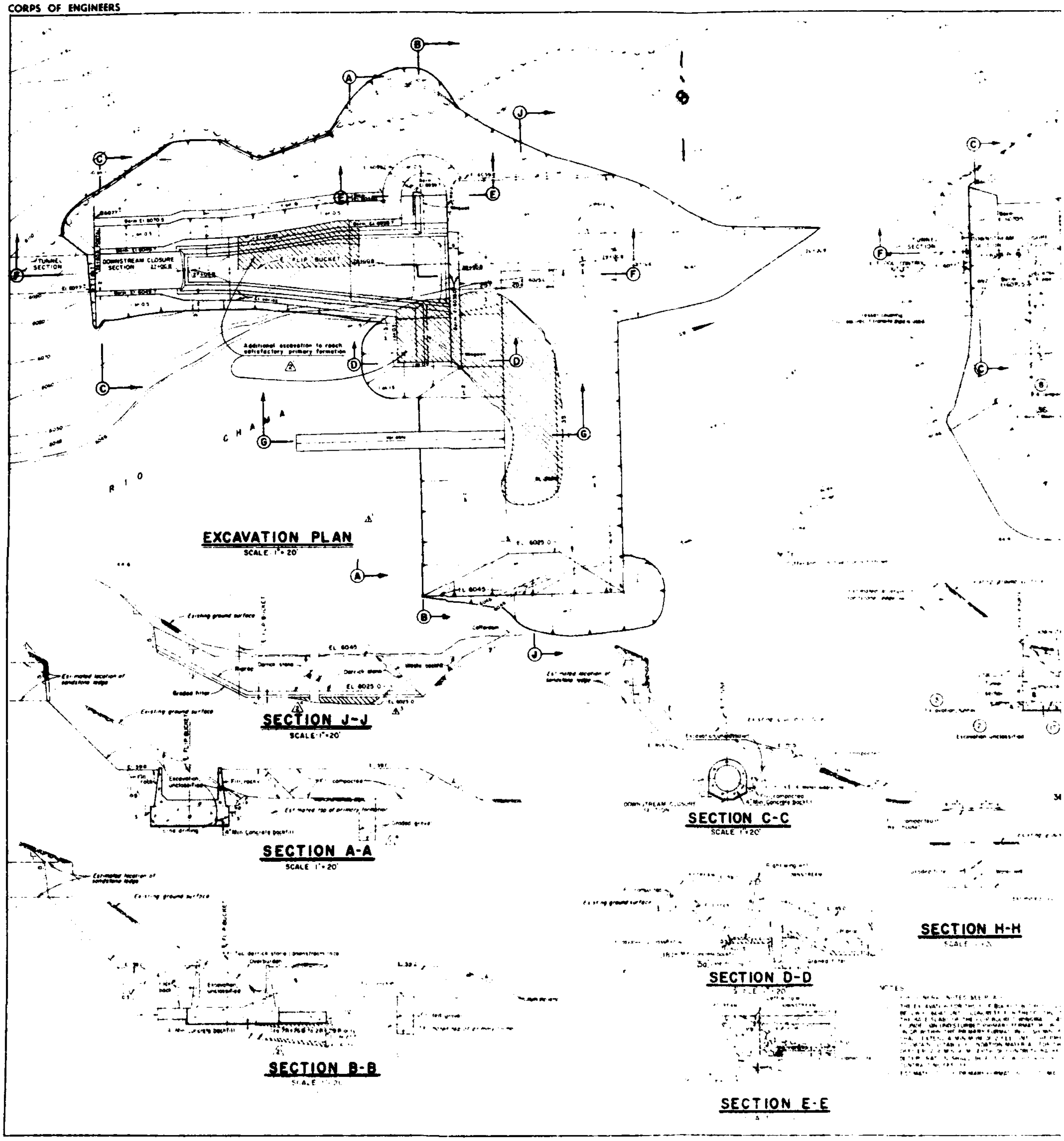
MECHANICAL EQUIPMENT

SCALE

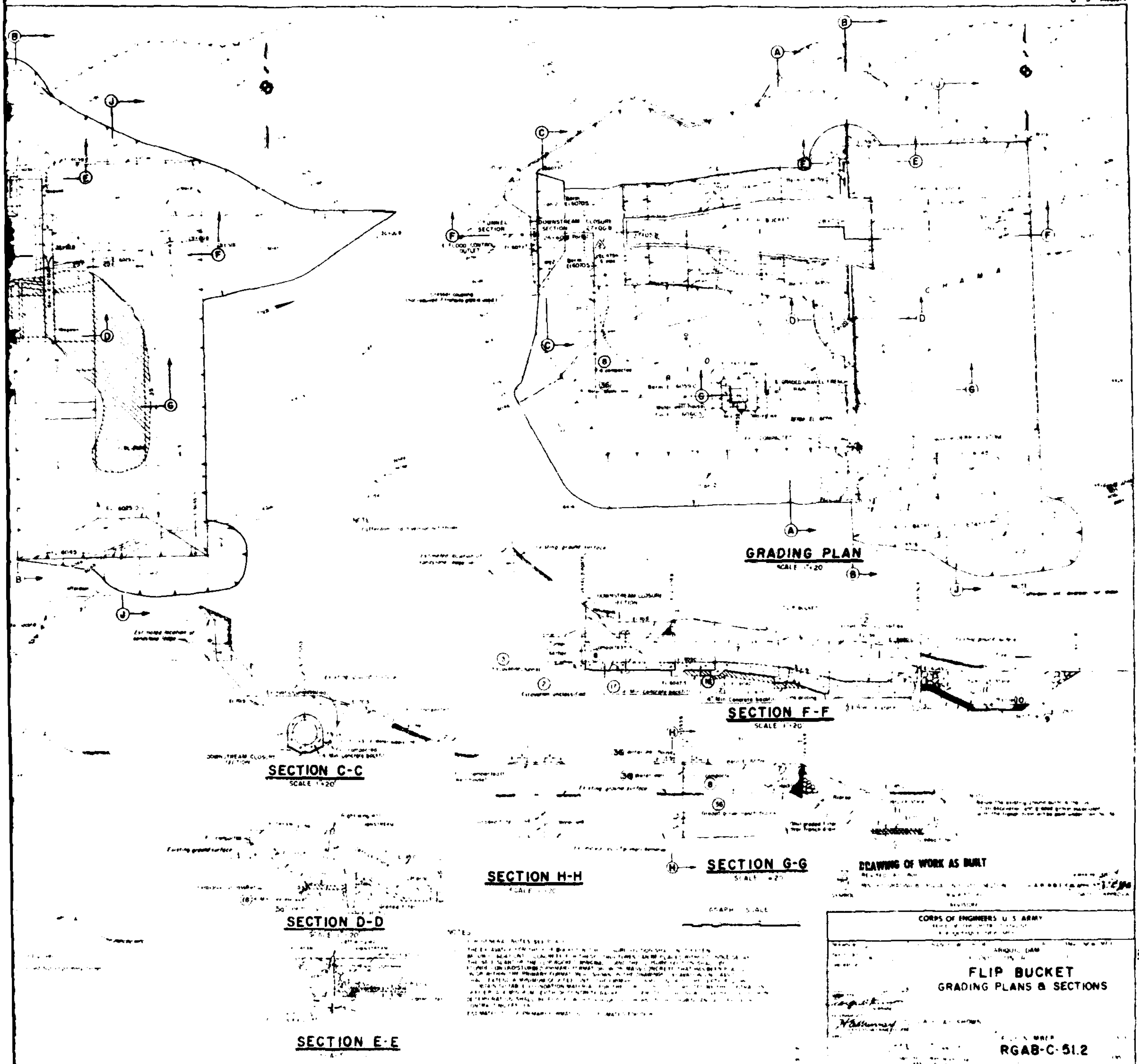
FILE NUMBER RGAB-C-30.1

PLATE 14

CORPS OF ENGINEERS



U. S. ARMY



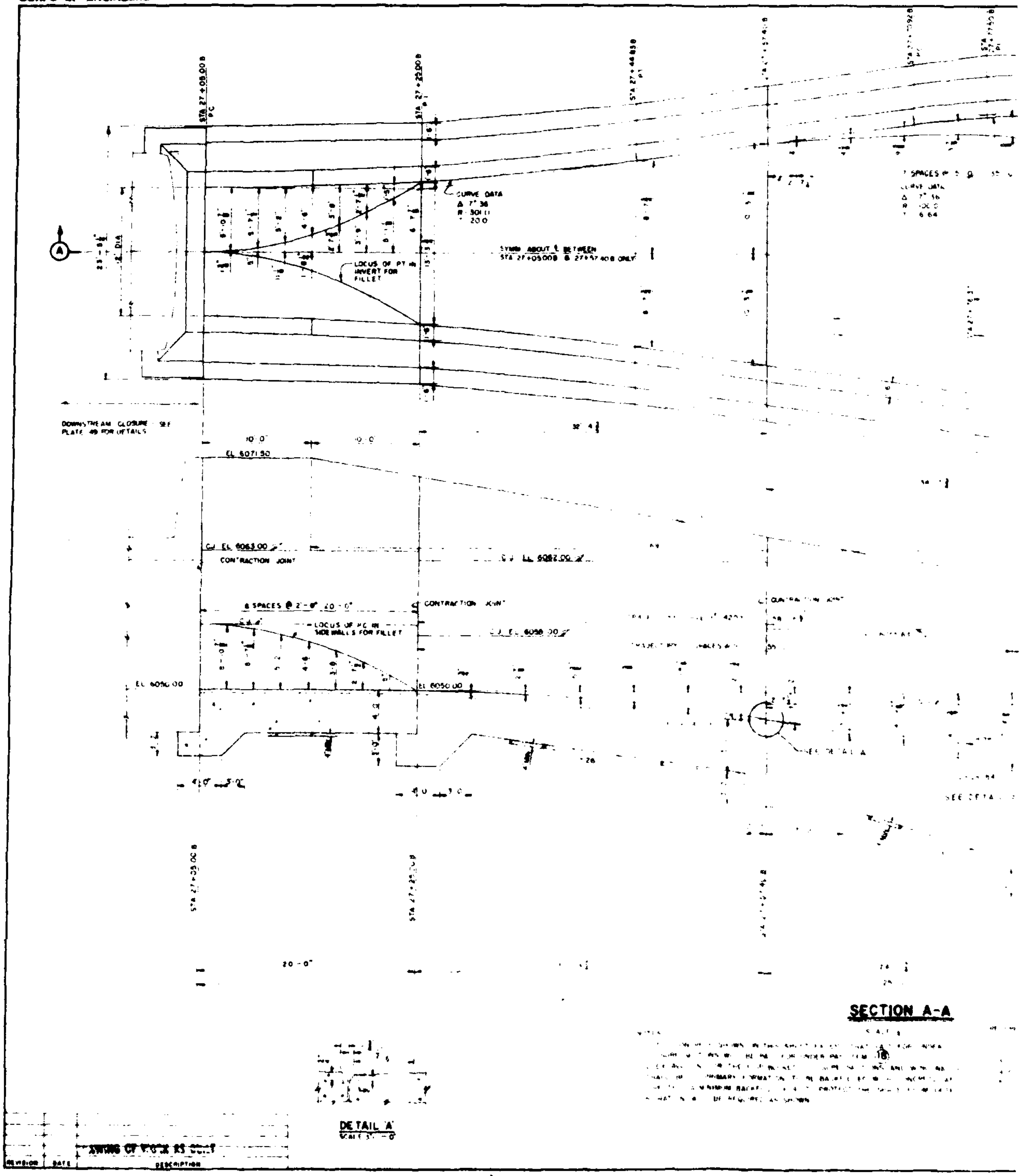
CORPS OF ENGINEERS U. S. ARMY

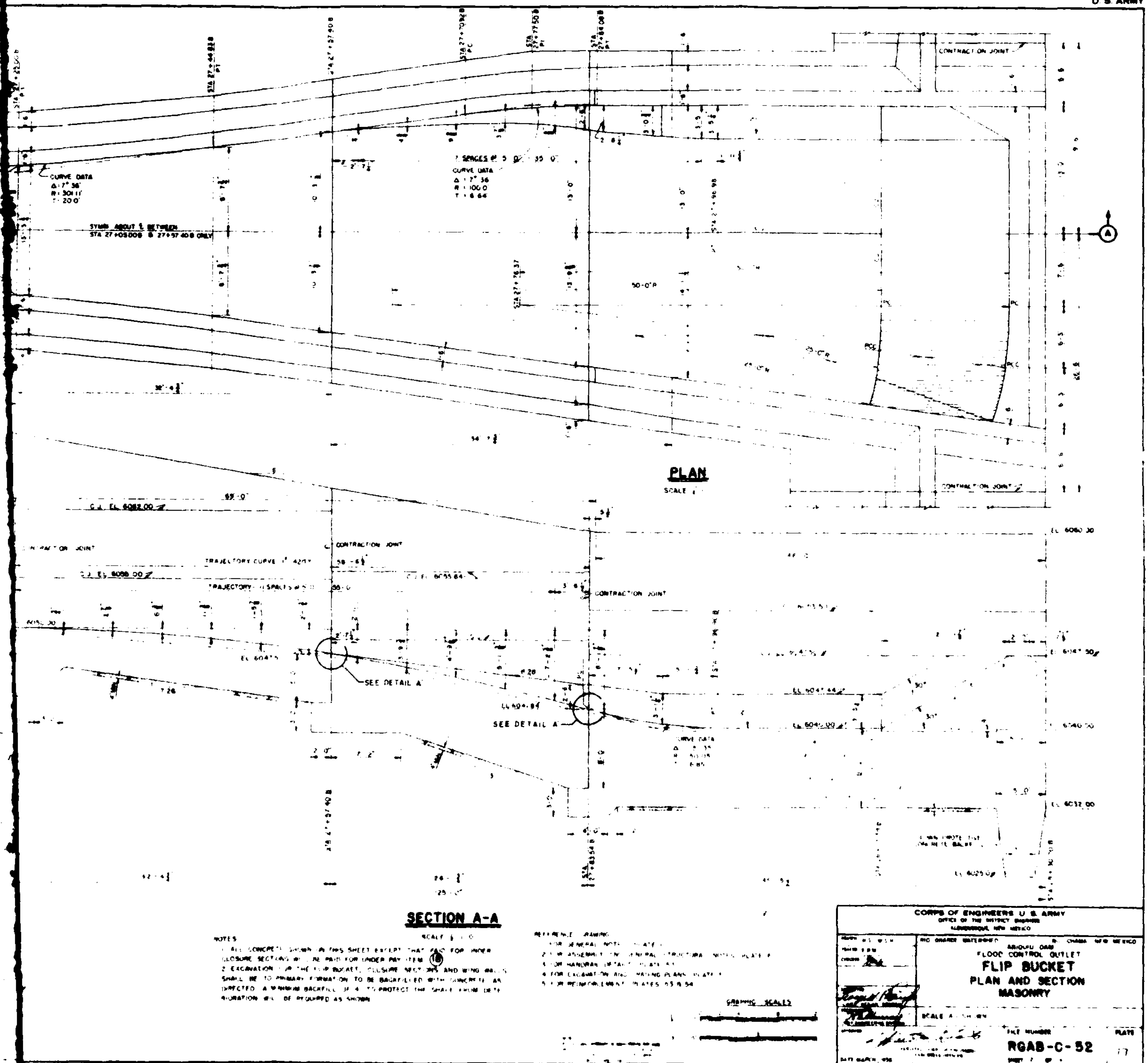
ABIQUIU DAM

FLIP BUCKET
GRADING PLANS & SECTIONS

RGAB-C-51.2

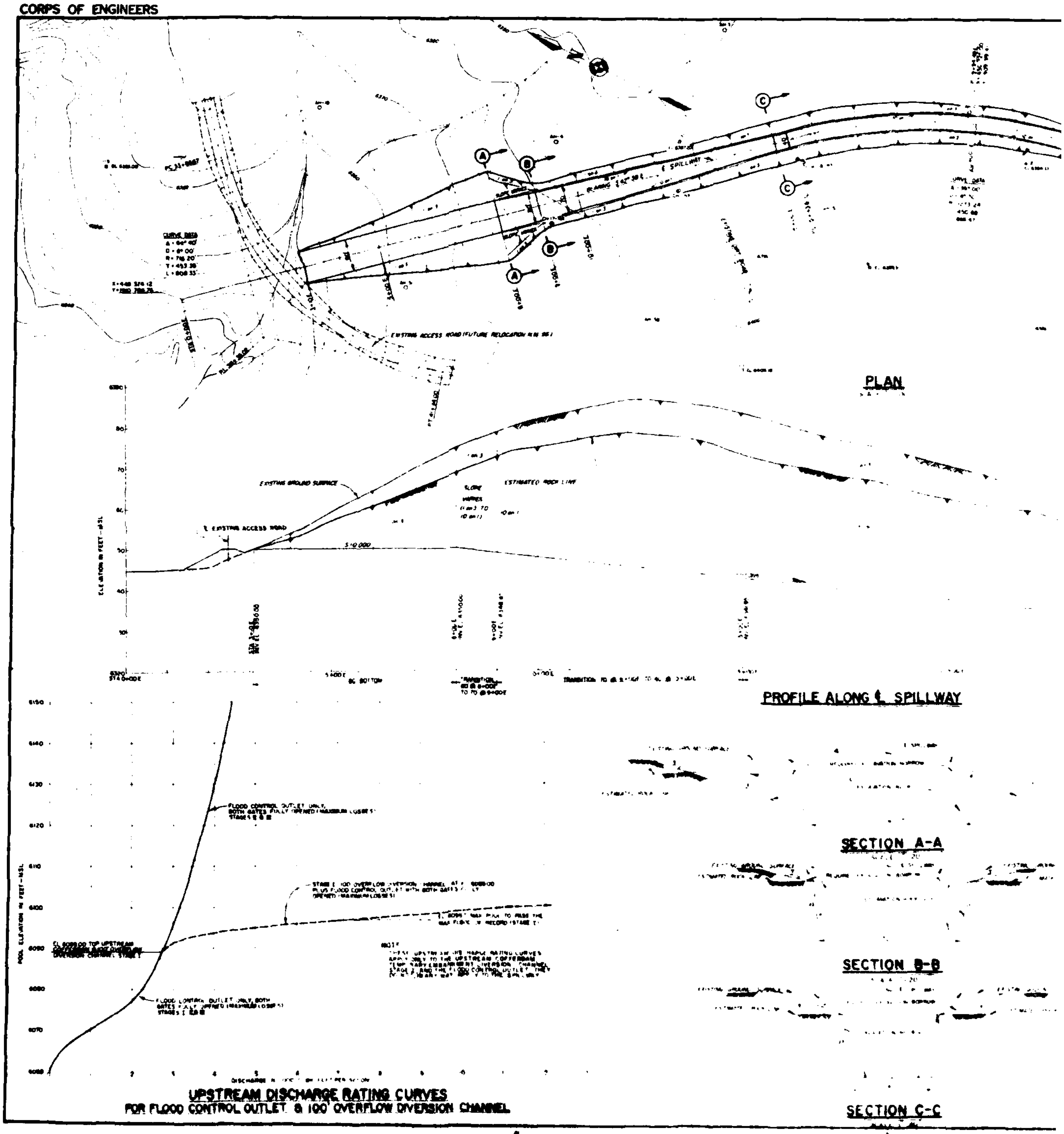
CORPS OF ENGINEERS

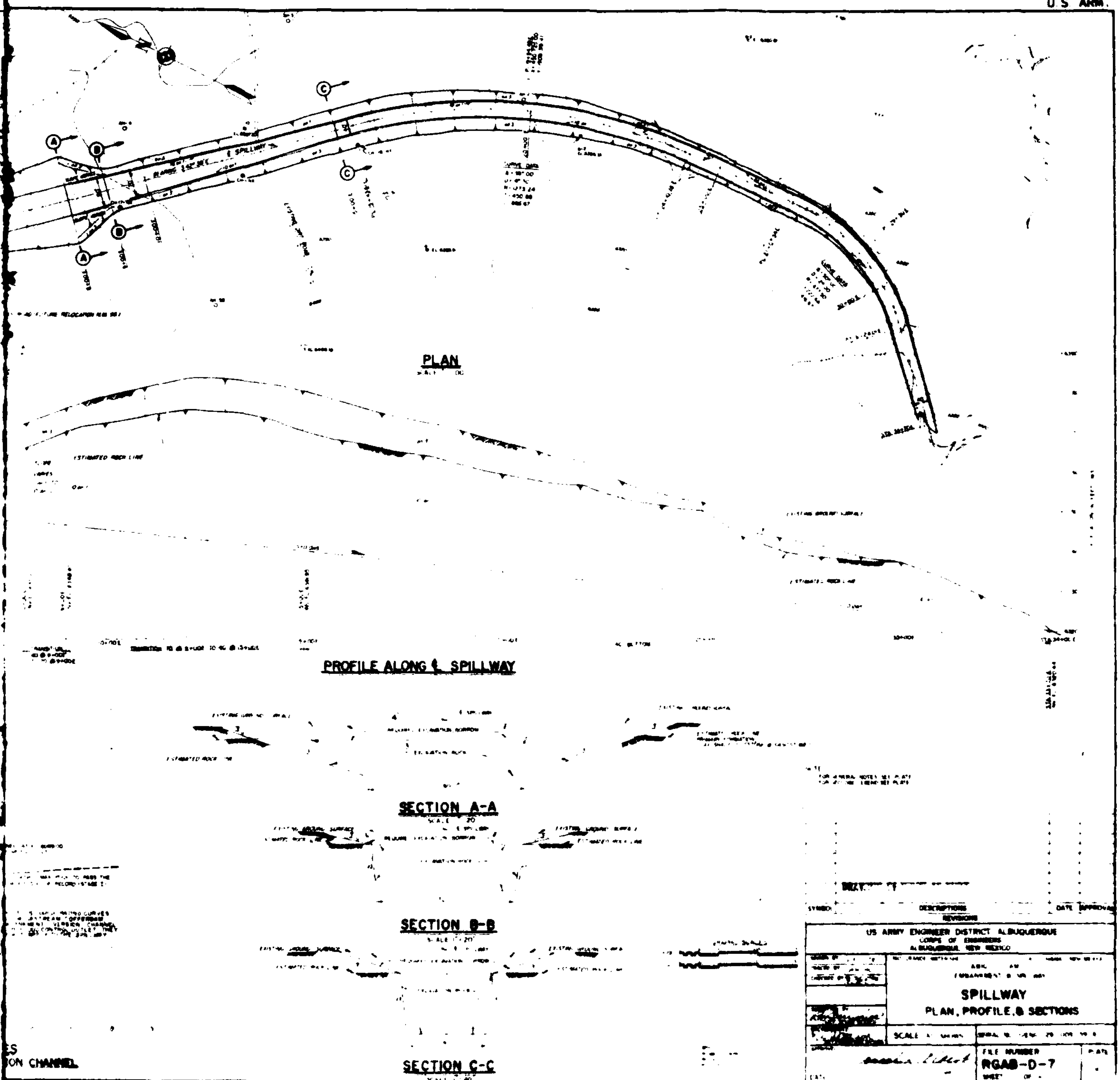


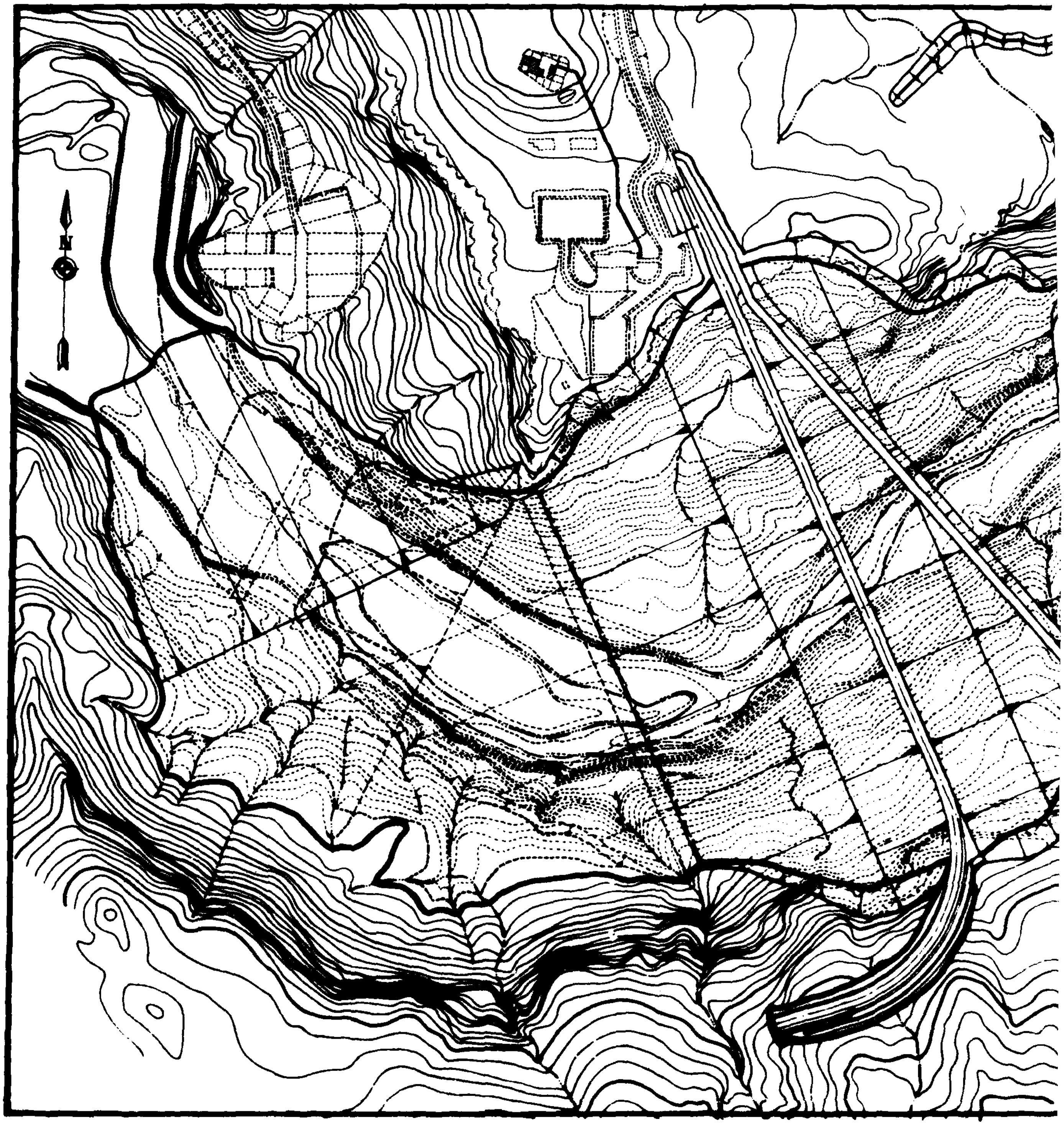

U S ARMY
CONTRACTION JOINT
CURVE DATA
SYMM ABOUT ℄ BETWEEN STA 27+05.00 B & 27+57.40 B ONLY
PLAN
CONTRACTION JOINT
TRAJECTORY CURVE
SEE DETAIL A
SEE DETAIL A
SECTION A-A
NOTES
REFERENCE DRAWING
GRAPHIC SCALES
CORPS OF ENGINEERS U S ARMY
FLOOD CONTROL OUTLET
FLIP BUCKET
PLAN AND SECTION
MASONRY
FILE NUMBER
PLATE
RGAB-C-52

2

CORPS OF ENGINEERS




U.S. ARMY
PLAN
ESTIMATED ROCK LINE
PROFILE ALONG ℄ SPILLWAY
SECTION A-A
SCALE 1"=20'
SECTION B-B
SECTION C-C
SYMBOL
DESCRIPTIONS
REVISIONS
DATE
APPROVAL
US ARMY ENGINEER DISTRICT, ALBUQUERQUE
CORPS OF ENGINEERS
ALBUQUERQUE, NEW MEXICO
SPILLWAY
PLAN, PROFILE, & SECTIONS
FILE NUMBER
RGAB-D-7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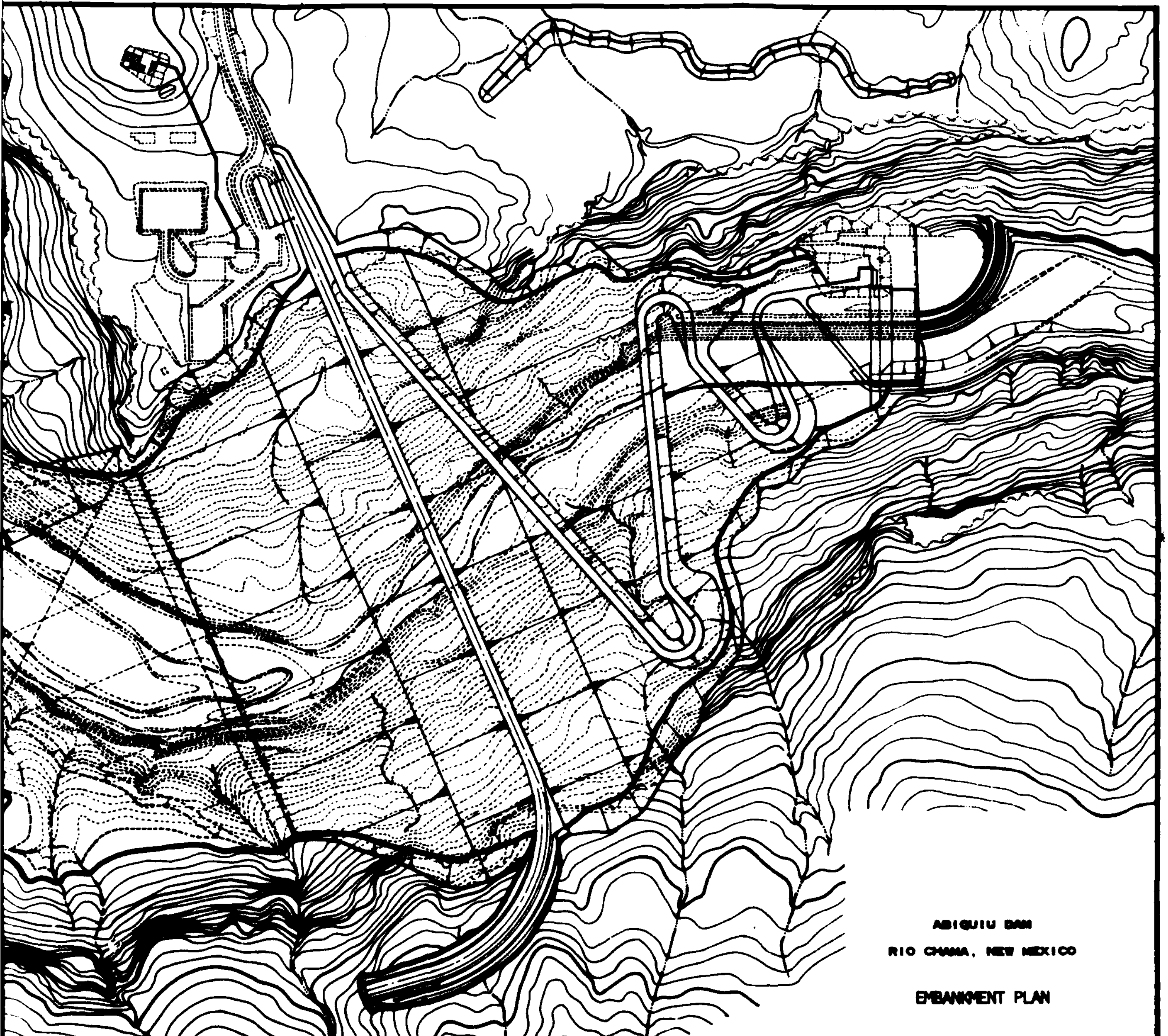
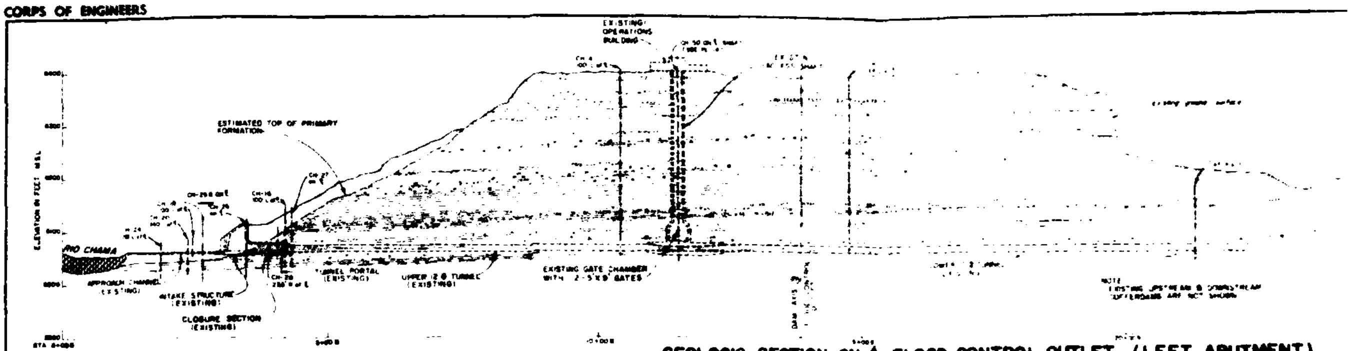
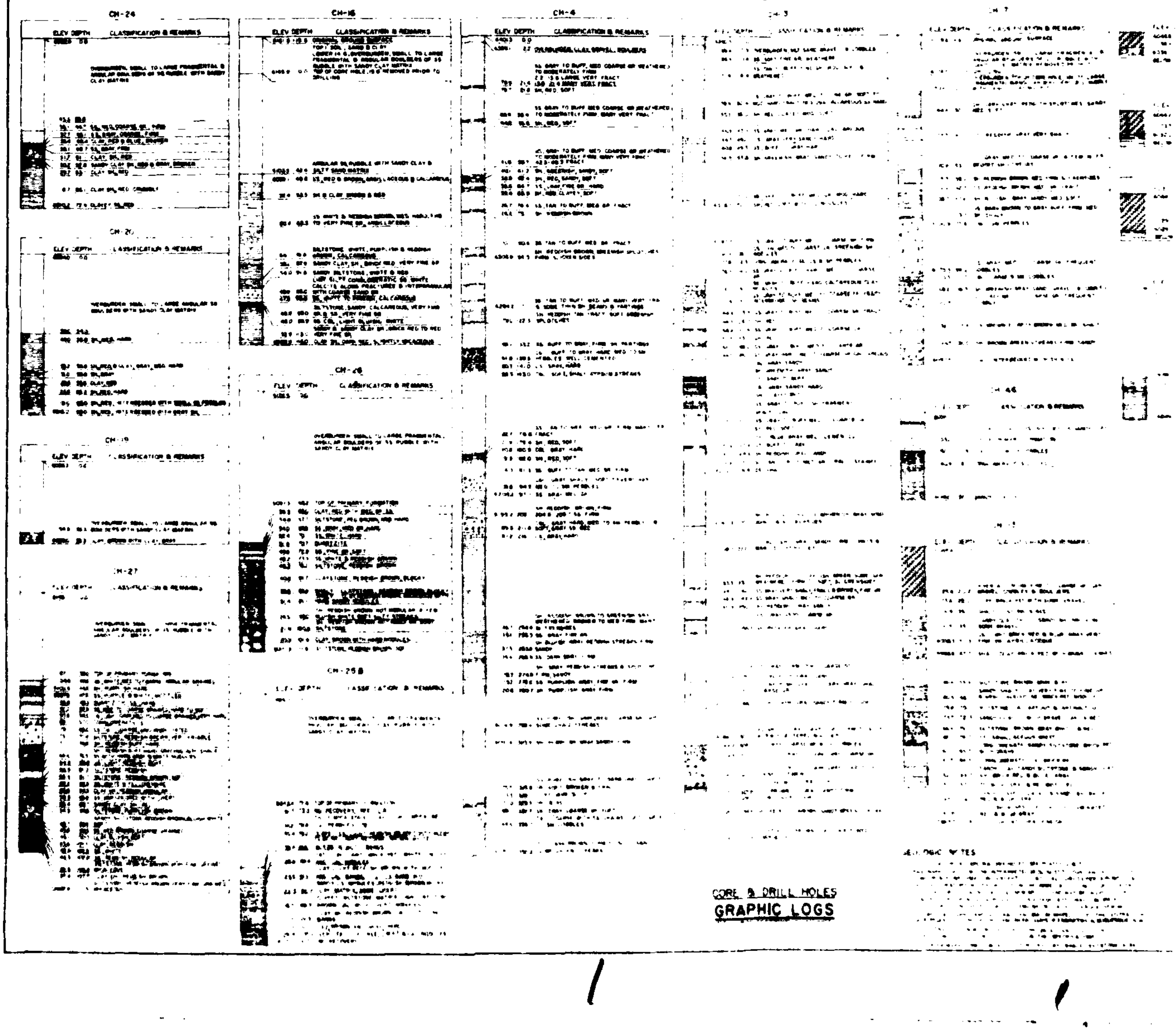

ABIQUIU DAM
RIO CHAMA, NEW MEXICO
EMBANKMENT PLAN

CORPS OF ENGINEERS

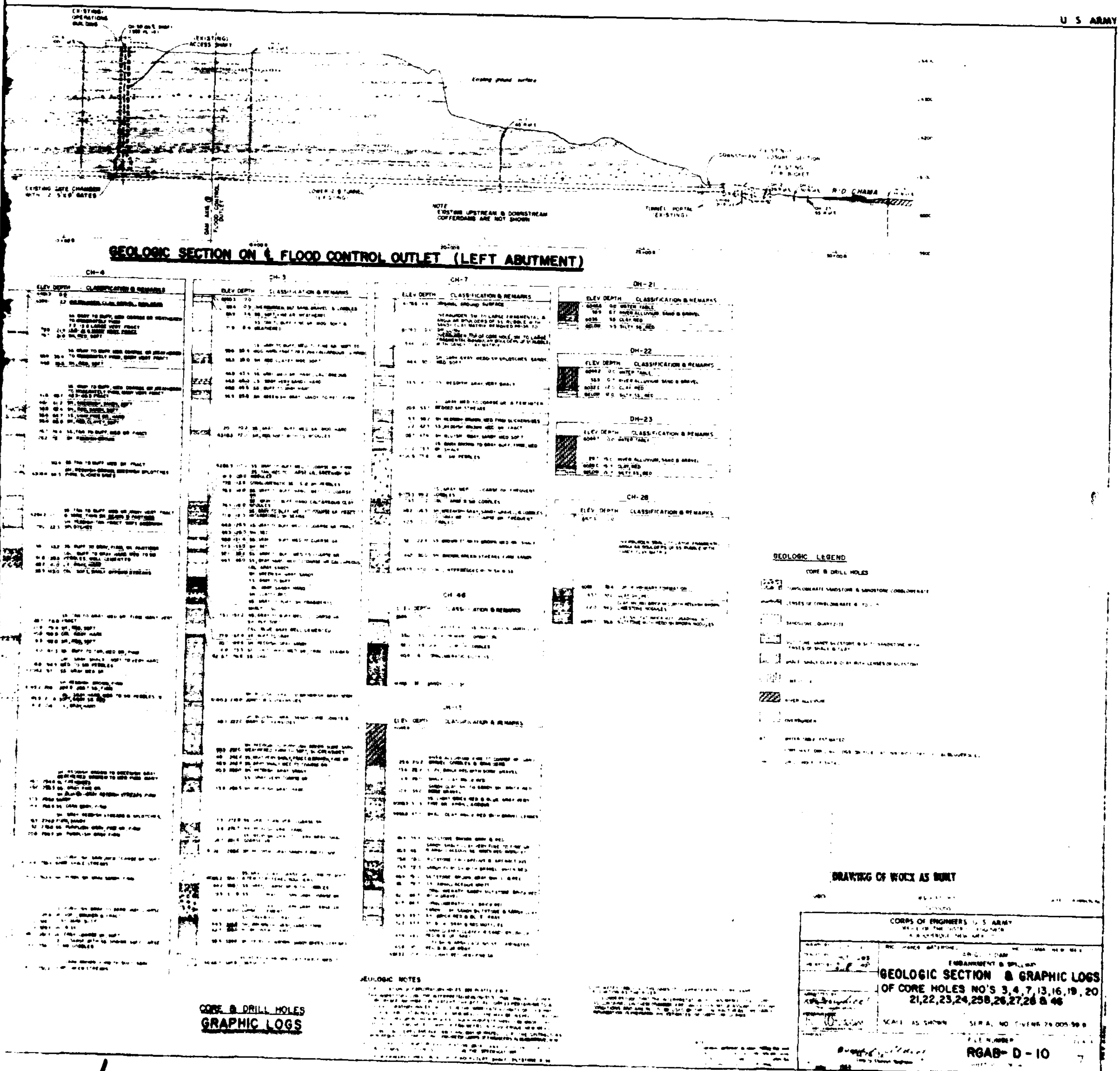


GEOLOGIC SECTION ON ¢ FLOOD CONTROL OUTLET (LEFT ABUTMENT)



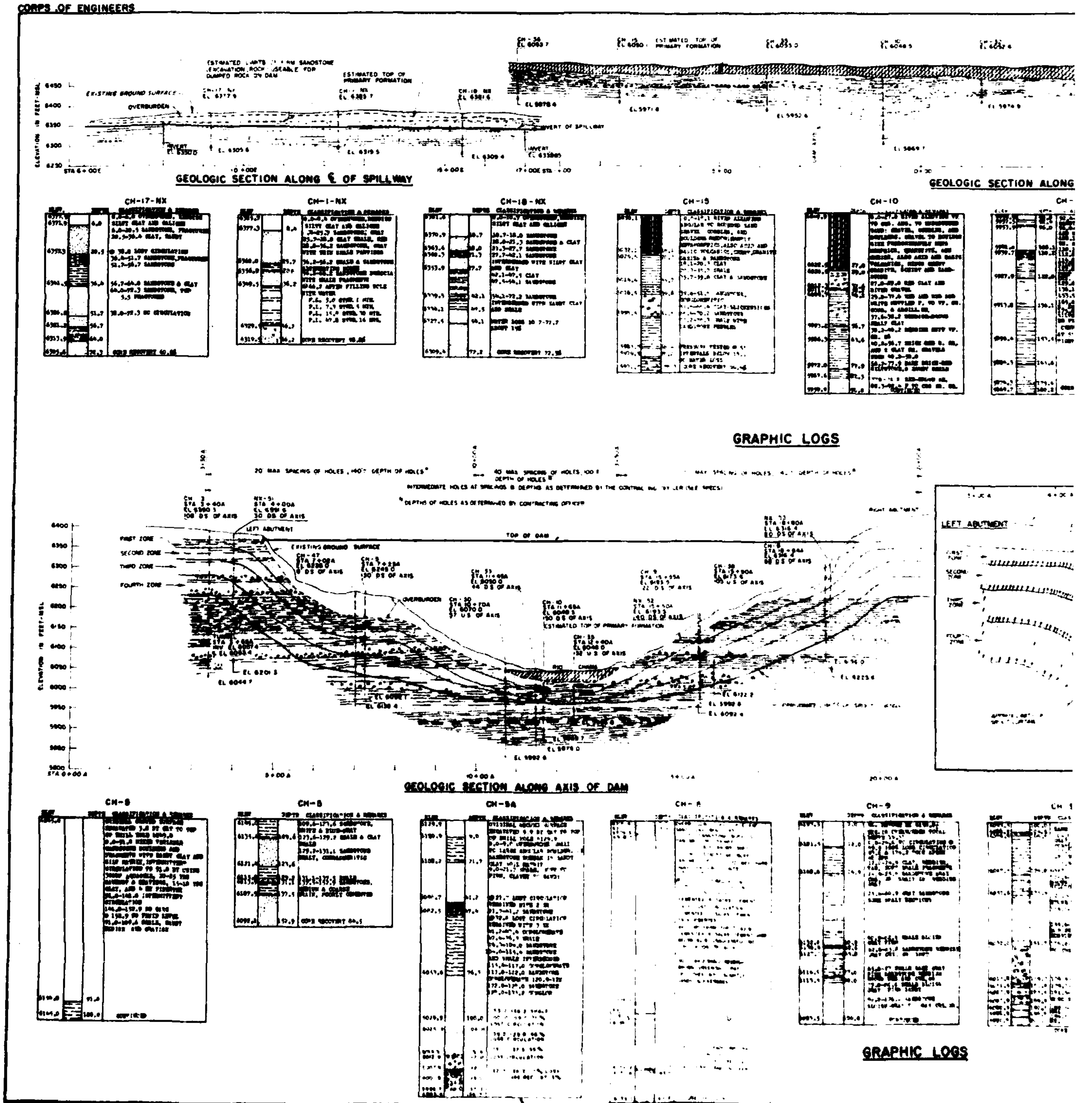
CORE & DRILL HOLES GRAPHIC LOGS

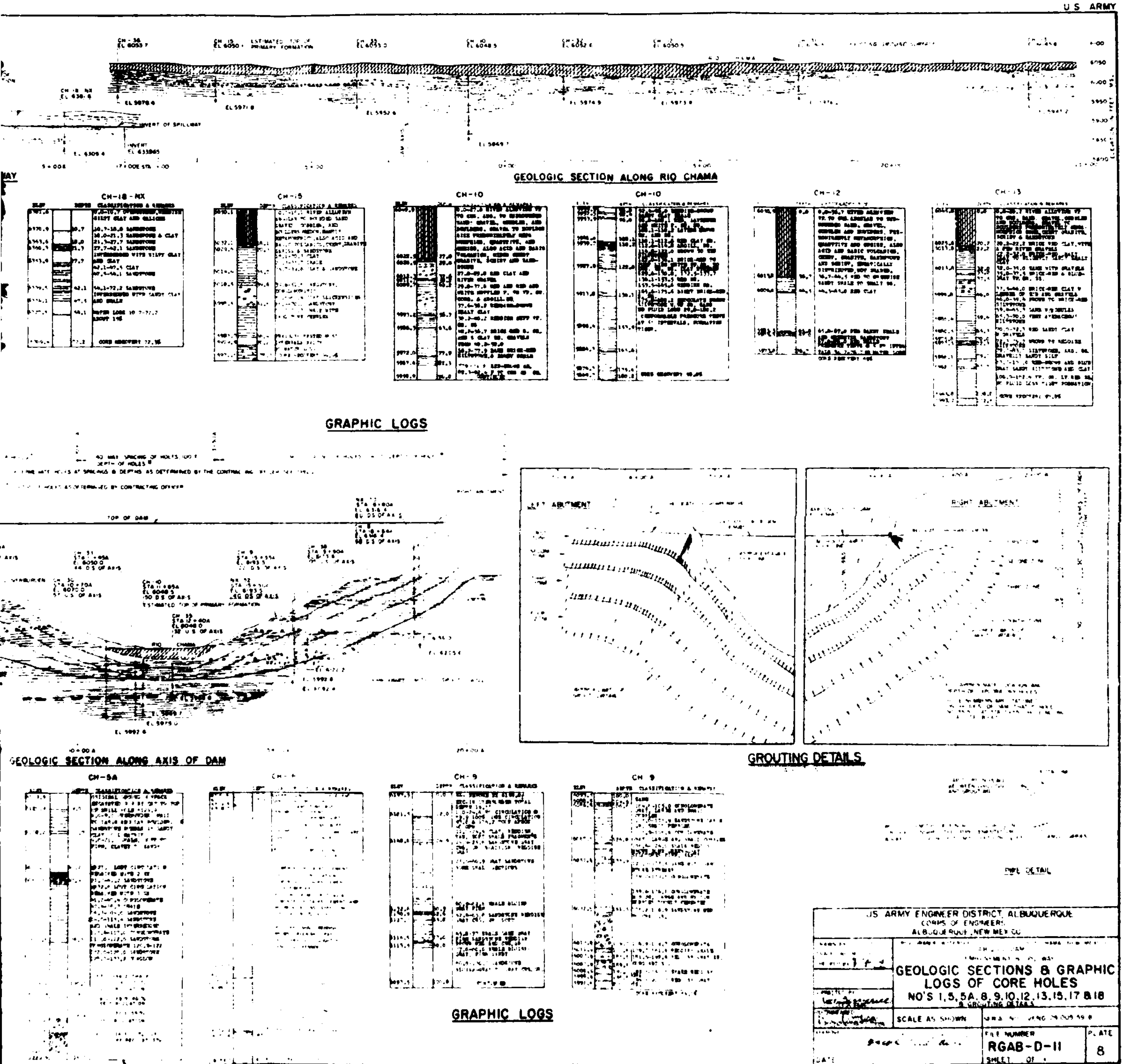
GEOLOGIC NOTES



EMBANKMENT CRITERIA AND PERFORMANCE REPORT PLATE 14

CORPS OF ENGINEERS




U S ARMY
GEOLOGIC SECTION ALONG RIO CHAMA
CH-18-NX
CH-15
CH-10
CH-10
CH-12
CH-13
GRAPHIC LOGS
LEFT ABUTMENT
RIGHT ABUTMENT
GEOLOGIC SECTION ALONG AXIS OF DAM
GROUTING DETAILS
CH-5A
CH-9
CH-9
GRAPHIC LOGS
US ARMY ENGINEER DISTRICT, ALBUQUERQUE
CORPS OF ENGINEERS
ALBUQUERQUE, NEW MEXICO
GEOLOGIC SECTIONS & GRAPHIC
LOGS OF CORE HOLES
NO'S 1, 5, 5A, 8, 9, 10, 12, 13, 15, 17 & 18
& GROUTING DETAILS
SCALE AS SHOWN
FILE NUMBER
RGAB-D-11
PLATE
8

CORPS OF ENGINEERS

Core Hole No. 29

DEPARTMENT OF THE ARMY — DIVISION SOUTHWESTERN — INSTALLATION ALBUQUERQUE DISTRICT — DRILLING LOG

Project: ABIQUIU DAM — Sheet 1 of 1
Location: N 447,629 - - E 1,905,860
Drilling agency: ALBUQUERQUE DISTRICT
Name of driller: C. C. WILDENSTEIN
Size and type of bit: 5-3/8" CORE
Manufacturer's designation of drill: WINTER-WEISS PORTADRILL
Date hole: 1956
Elevation top of hole: [illegible]
Total core recovery for boring: 86.0
Signature of inspector: TONY VELARDE

Elevation	Depth	Classification of materials	% Core recovery	Box or sample no.	Remarks
	0.0	SILT, SAND, SANDSTONE RUBBLE, SOME CLAY			HOLE CAVED
					@ 5.1' SET 8" ID Csg
					LOST CIRCULATION @ 13.0
					100% WATER LOSS USING VERY HEAVY MUD
		SANDSTONE RUBBLE AND CLAY			@ 19.4 - 100% F/L 23.6
					F/L 25.4 @ 28.0
		CLAY, AND SANDSTONE RUBBLE			CEMENTED W/12 SKS. @ 31.5 F/L 27.0
					@ 41.0 NO FLUID IN HOLE
		SANDSTONE RUBBLE AND CLAY			100% FLUID LOSS
					15.5-56.4 W/ NX BIT 5,000 GAL WATER CONSUMED
					56.4-64.7 USED 5,000 GALS WATER
		BROKEN SS. AND COBB.	100	BOX 1	100 % WATER LOSS
		SILTY CLAY	95		
		SILTSTONE	96	BOX 2	
		SILTY CLAY	97	BOX 3	
		SILTY SANDSTONE	100	BOX 4	
			100	BOX 5	
		SILTY SANDSTONE AND CONGLOMERATE	100	BOX 6	
	73.8		100	BOX 7	

Core Hole No. 30

DEPARTMENT OF THE ARMY — DIVISION SOUTHWESTERN — INSTALLATION ALBUQUERQUE DISTRICT — DRILLING LOG

Project: ABIQUIU DAM — Sheet 1 of 1
Location: N 448,050 - - E 1,905,990
Drilling agency: ALBUQUERQUE DISTRICT
Hole no.: 30
Name of driller: C. C. WILDENSTEIN
Thickness of overburden: 26.5 — Total depth of hole: 77.4
Size and type of bit: 5-3/8" CORE
Datum for elevation shown: MSL
Manufacturer's designation of drill: WINTER-WEISS PORTADRILL
Total no. of core boxes: 11
Date hole: 56 / 57
Elevation top of hole: 6070.0
Total core recovery for boring: 99.0
Signature of inspector: TONY VELARDE

Elevation	Depth	Classification of materials	% Core recovery	Box or sample no.	Remarks
6070	0.0	SANDSTONE RUBBLE			SET 6 SACKS CEMENT AT 12.6
					12.6-26.5 NO WATER LOSS
6043.5	26.5	SILTY CLAY			
	27.4	CLAY AND SILTY SANDSTONE	100	BOX 1	
	31.7	SILTY CLAY			
	32.3	SILTY SANDSTONE BADLY FRACTURED	100	BOX 2	LOST CIRCULATION F/L 31.1
			100	BOX 3	
	40.8	COARSE MED. HARD SANDSTONE	100	BOX 4	WATER CONSUMPTION 1000 GALS
			100	BOX 5	
	47.7	SOFT SILTY SANDSTONE			
	48.4	HARD COARSE GR. SANDSTONE	100	BOX 6	
	57.1	SILTY SHALE	100	BOX 7	
		SILTY SANDSTONE SOME LAYERS OF SHALE	98	BOX 8	
	63.2	LAYERS OF SHALE SILTSTONE AND SANDSTONE	100	BOX 9	
	67.0	SHALE	100	BOX	
		SANDSTONE	98	10	
	73.4	FINE SILTY SANDSTONE			
	75.9	SHALE	100	BOX 11	
5992.6	77.4	SILTSTONE			BOTTOM HOLE 77.4

Core Hole No. 31

DIVISION SOUTHWESTERN CORPS OF ENGINEERS — INSTALLATION ALBUQUERQUE DISTRICT — DRILLING LOG

Project: ABIQUIU DAM
Location: [illegible]
Drilling agency: ALBUQUERQUE DISTRICT
Hole no.: 31
Name of driller: CLARENCE C. WILDENSTEIN
Size and type of bit: 5-5/8" CARBOLOY
Manufacturer's designation of drill: WINTER-WEISS PORTADRILL
Total no. of core boxes: 11 BAGS
Elevation top of hole: 6051.5
Total core recovery for boring: 96.0
Signature of inspector: TONY S. VELARDE

Elevation	Depth	Classification of materials	% Core recovery	Box or sample no.	Remarks
		BUILT UP W. FILL MATERIAL FOR DRILLING PLATFORM			12" I.D. CSNG, 7" I.D. CSNG LEFT IN HO[LE]
6047.5	4.0	RIVER ALLUVIUM GR. TO COBS. ANGULAR TO ROUNDED SAND, GRAVEL, COBBLES, A FEW BOULDERS. GRAVEL TO BOULDER SIZE, PREDOMINENTLY METAMORPHIC, ALSO ACID AND BASIC VOLCANICS, CHERT, GRANITE, GNEISS, SCHIST AND SANDSTONE		11 BAG SAMPLES	4.0-28.0 12" PIPE DRIVEN AT INTERVALS AND CLEANED W. GRAB BUCKET.
					NO WATER LOSS 28.0 FT.
6023.5	28.0	SILTY SANDSTONE W. CLAY PARTICLES	100	1	WAXED SAMPLES 28.0-30.1, 40.3-41.7, 42.7-44.3, 45.9-47.4, 48.4-50.8, 50.8-51.9, 51.9-53.0, 58.0-59.9, 62.4-63.6, 64.8-66.2, 73.8-75.3
6016.4	35.1		100		
		SANDSTONE INTERBEDDED W. SILTSTONE, AND CLAY SHALE	100	2	
6010.7	40.8		100	3	
		SHALY CLAY - BADLY FRACTURED	100	4	
6006.9	44.6	SHALY CLAY	100	5	
6002.9	48.6				
5998.5	53.0	CLAY	98	6	
		CLAY AND SHALY CLAY W. BLUE SHALE STREAKS	100	7	
5993.5	58.0	SILTSTONE	90	8	
5989.1	62.4				
5985.5	66.0	SILTY SANDSTONE	87	9	
5980.6	70.9	SHALE - BADLY FRACTURED	100	10	
5976.2	75.3	SHALY CLAY	100	11	

Core Hole No. 33

DEPARTMENT OF THE ARMY — DIVISION SOUTHWESTERN — INSTALLATION ALBUQUERQUE DISTRICT — DRILLING LOG

Project: ABIQUIU DAM — Sheet 1 of 1
Location: 448,182 E 1,905,965 T
Drilling agency: ALBUQUERQUE DISTRICT
Hole no.: 33
Name of driller: C. C. WILDENSTEIN
Thickness of overburden: 26.7 — Total depth of hole: 75.0
Size and type of bit: 5-3/8" ABRICOT CORE
Manufacturer's designation of drill: PORTADRILL
Total no. of core boxes: 11
Date hole: started 10 JAN 57, completed 16 JAN 57
Elevation top of hole: 6050.0
Total core recovery for boring: 86.5
Signature of inspector: TONY VELARDE

Elevation	Depth	Classification of materials	% Core recovery	Box or sample no.	Remarks
6050.0	0.0	OVERBURDEN RIVER ALLUVIUM + 1' OF CLAY			@ 12.8 LANDED 8" at 5.0
					@ 12.8 LANDED 8" at 12.2
					NO FLUID LOSS TO 22.8
	22.0				HOLE OPEN TO 19.4
	23.5	MED. GR. SOFT SANDSTONE			
6025.3	26.7	COBBLES AND CONGLOMERATE			@ 29.4 HOLE CAVED TO 24.5
		COARSE GR. SANDSTONE	80	BOX 1	@ 38.4 HOLE CAVING TO 32.5
	29.8	COBBLES			
		VERY HARD CRS. SANDSTONE	90	BOX 2	NO FLUID LOSS
	35.2	CONGLOMERATIC SS	100	BOX 3	WAXED 38.4-39.9, 41.7-43.2
	37.2	SANDSTONE			
	39.4	SHALE AND CLAY			
		CLAY	70	BOX 4	WAXED 55.0-56.4, 56.4-59.0
	44.7	SHALY CLAY	70	BOX 5	NO FLUID LOSS
	48.2	SILTY SHALE	80	BOX 6	
			60	BOX 7	
	58.0	HARD SHALE	100	BOX 8	
	60.0	SANDSTONE			
	62.0	SHALE AND SHALY CLAY	80	BOX 9	
			75	BOX 10	
5975.0	75.0		60	BOX 11	NO FLUID LOSS, BOTTOM OF HOLE

Core Hole No. 34

DEPARTMENT OF THE ARMY — DIVISION SOUTHWESTERN — INSTALLATION ALBUQUERQUE DISTRICT — DRILLING LOG

Project: ABIQUIU DAM — Sheet 1 of 1
Location: N 448,100 - - E 1,905,[illegible]
Drilling agency: ALBUQUERQUE DISTRICT
Hole no.: #34
Name of driller: C. C. WILDENSTEIN
Direction of hole: VERTICAL 0.0
Thickness of overburden: 0.0 — Total depth of hole: 87.0
Size and type of bit: 5-3/8" CORE BBL.
Datum for elevation shown: MSL
Manufacturer's designation of drill: PORTADRILL
Total no. of core boxes: 12
Date hole: NOV 56
Elevation top of hole: 6086.3
Total core recovery for boring: 81.5
Signature of inspector: [illegible]

Elevation	Depth	Classification of materials	% Core recovery	Box or sample no.	Remarks
6086.3	0.0	LT. BRICK RED SHALE [illegible] SANDY 1.0-2.0 AND 3.5-4.0	NO RECOVERY		0.0-5.0 NO F/L
	5.0	[illegible]	100	BOX 1	6.0-8.6 WAXED
	10.5	[illegible]			5.0-10.5 NO FLUID LOSS
	11.8	[illegible]	98	BOX 2	10.5-31.0 NO FLUID LOSS
	14.6	SAND			31.0-37.9 NO F/L
	17.3	[illegible]	98	BOX	
	19.2	[illegible]	100	BOX 3	37.9-43.0 NO RECOVERY
		[illegible] SALT AND PEPPER TEXTURED SOFT, SILTY AND TO F. GR. [illegible] 27.0-29.1	100	BOX 4	37.9-56.3 NO F/L; @ 56.3 FLUID LEVEL 24.5 HOLE OPEN 55.1 [illegible]
	31.0		91	BOX 5	@ 58.7 F/L 55 [illegible]
	32.5	[illegible]			
	34.2	[illegible]	94	BOX 6	@ 58.7 F/L 28.3 [illegible] OPEN TO 58 HOLE [illegible] AT 57.7
	36.6	[illegible]			
	37.9	CONGLOMERATE OR CONGLOMERATIC SILTSTONE	NO RECOVERY		@ 59.0 HOLE CAVING FLUID LEVEL 19.5
	43.0	[illegible]			
	44.7	[illegible]		BOX 7	[illegible]
	46.3	[illegible]			
	49.0	[illegible]	100	BOX 8	
	51.0	[illegible]			
	53.0	[illegible]			
	56.5	[illegible]	90	BOX 9	[illegible] CEMENTED W/ [illegible]
	58.2	[illegible]			
	59.4	NO RECOVERY 59.4[illegible]	NO RECOVERY		NO FLUID LOSS
		[illegible]	100	BOX 10	
	66.4	[illegible]			
		[illegible]	61	BOX 11	
	72.7	[illegible], FAT CLAY SHALE			
	76.5	[illegible] CLAY AND CLAY SHALE	[illegible]	BOX 12	
	81.8	[illegible]			
[illegible]	87.0	BOTTOM OF HOLE			

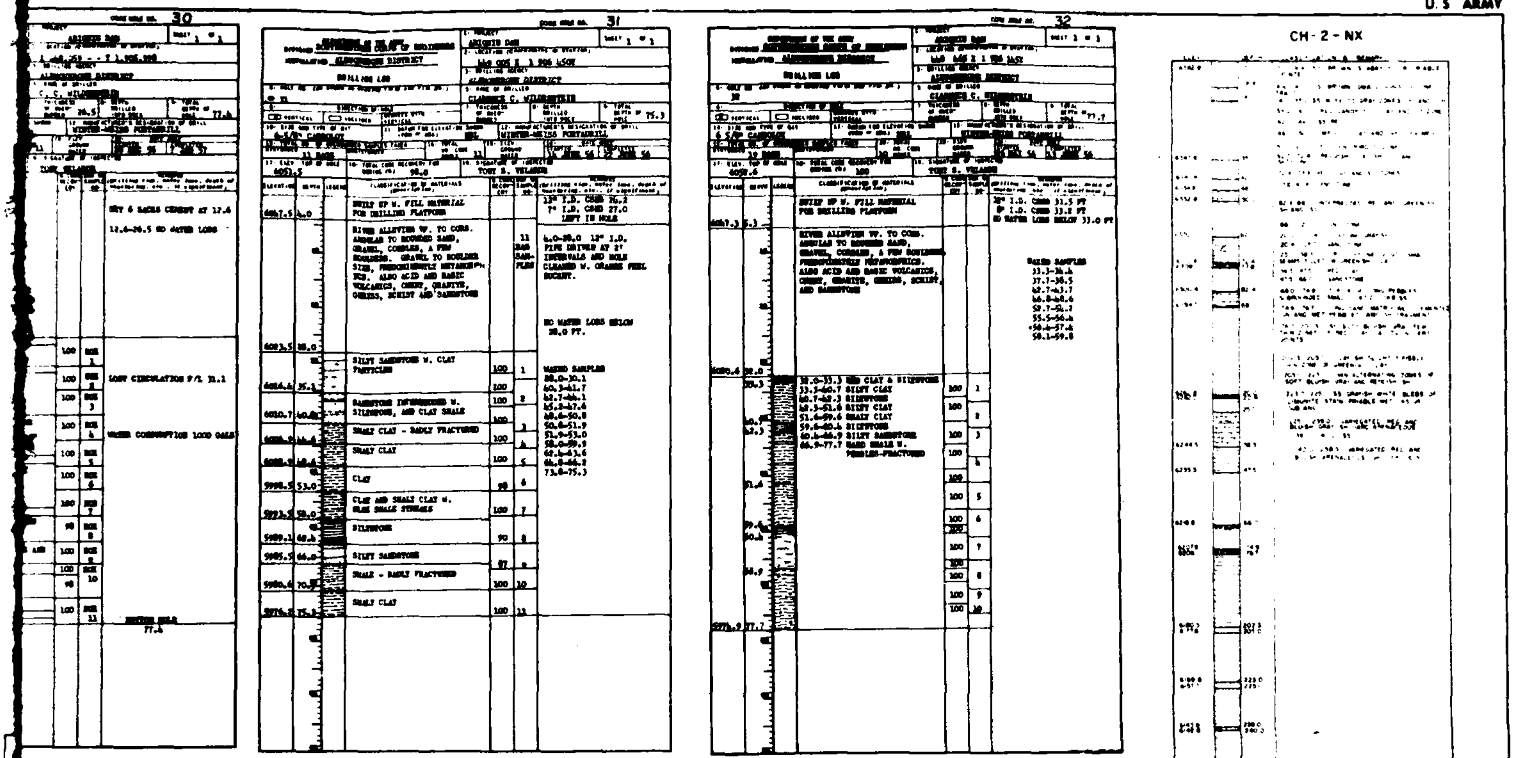
Core Hole No. 35

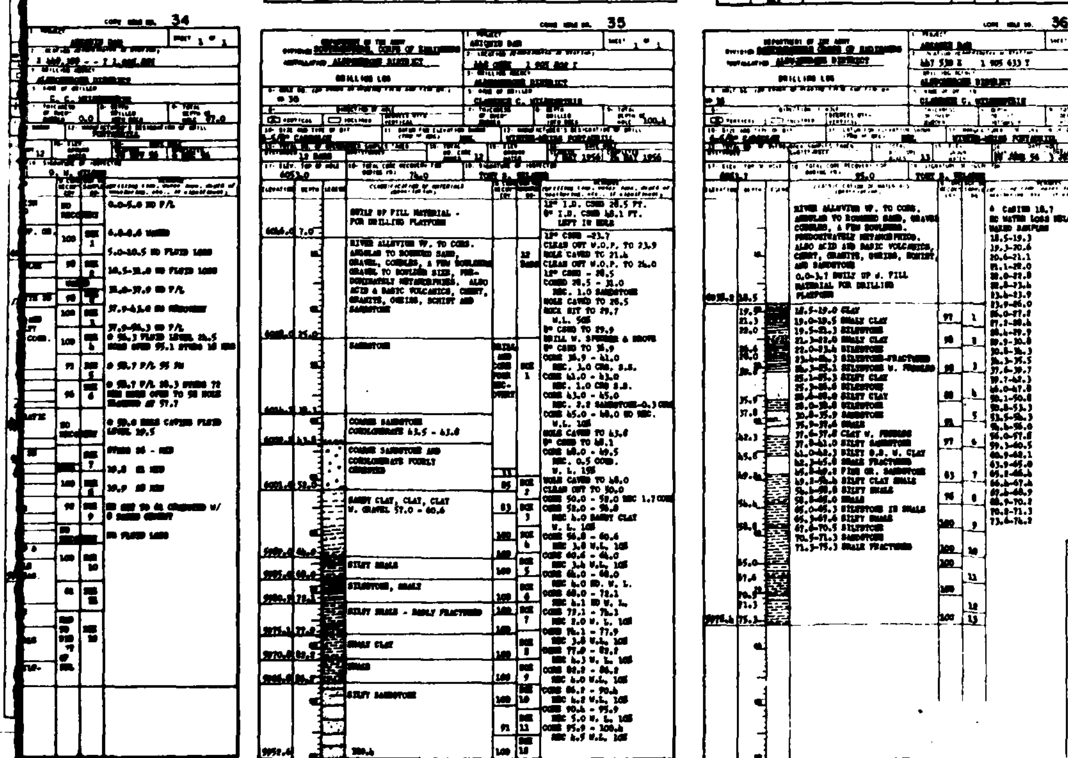
DEPARTMENT OF THE ARMY — DIVISION SOUTHWESTERN, CORPS OF ENGINEERS — INSTALLATION ALBUQUERQUE DISTRICT — DRILLING LOG

Project: ABIQUIU DAM
Drilling agency: ALBUQUERQUE DISTRICT
Hole no.: 35
Name of driller: CLARENCE C. WILDENSTEIN
Size and type of bit: 5-5/8" CARBOLOY
Manufacturer's designation of drill: WINTER-WEISS PORTADRILL
Total no. of core boxes: 12 BAGS
Date hole: 1956
Elevation top of hole: 6053.0
Signature of inspector: TONY S. VELARDE

Elevation	Depth	Classification of materials	% Core recovery	Box or sample no.	Remarks
		BUILT UP FILL MATERIAL - FOR DRILLING PLATFORM			12" I.D. CSNG, 8" I.D. CSNG LEFT IN HOLE
6046.0	7.0	RIVER ALLUVIUM GR. TO COBS. ANGULAR TO ROUNDED SAND, GRAVEL, COBBLES, A FEW BOULDERS. GRAVEL TO BOULDER SIZE, PRE-DOMINENTLY METAMORPHICS, ALSO ACID & BASIC VOLCANICS, CHERT, GRANITE, GNEISS, SCHIST AND SANDSTONE		12 BAGS	[illegible]
6028.0	25.0	SANDSTONE	[illegible]	BOX 1	[illegible]
		COARSE SANDSTONE CONGLOMERATE 43.5 - 43.8			[illegible]
		COARSE SANDSTONE AND CONGLOMERATE POORLY CEMENTED			[illegible]
6001.0	52.0	SANDY CLAY, CLAY, CLAY W. GRAVEL 57.0 - 60.4	83	BOX 2, 3	[illegible]
		SILTY SHALE	100	BOX 4, 5	[illegible]
		SILTSTONE, SHALY	100	BOX 6	[illegible]
		SILTY SHALE - BADLY FRACTURED	100	BOX 7	[illegible]
		SHALY CLAY	100	BOX 8	[illegible]
		SHALE	100	BOX 9	[illegible]
		SILTY SANDSTONE	100	BOX 10	[illegible]
			91	BOX 11	[illegible]
5952.4	100.6		100	BOX 12	[illegible]

U. S. ARMY





NOTE
FOR GEOLOGIC NOTES AND LEGEND SEE PLATE [illegible]

US ARMY ENGINEER DISTRICT, ALBUQUERQUE CORPS OF ENGINEERS ALBUQUERQUE, NEW MEXICO		
DRAWN BY GLP CFJ TRACED BY JKH HLT CHECKED BY	RIO GRANDE WATERSHED — RIO CHAMA, NEW MEXICO ABIQUIU DAM EMBANKMENT & SPILLWAY **GRAPHIC LOGS OF CORE HOLES NO'S 2,29,30,31,32,33,34,35 & 36**	
SUBMITTED BY	SCALE AS SHOWN	SERIAL NO. CIVENG-29-005-59-8
APPROVED DATE	FILE NUMBER RGAB-D-12 SHEET 2 OF 4	PLATE 12

DRILLING LOG

TONY VILLAREAL

6 5/8" [illegible]

Elevation	Depth	Classification of materials (description)	% Core recovery	Box or sample no.	Remarks
6211.9		LARGE COBBLES OR SANDY SILTY SOIL	0.0		ORIGINAL GROUND SURFACE TRACTOR EXCAVATION FOR DRILL PLATFORM
6209.9	0.0	CLAY AND COBBLES			0.0 - 5.0 WITH 9-1/2" R.R. BIT.
	5.0	SANDSTONE, BUFF TO GRAY, RED OR, FRACTURED	50%	1	100% F/L @ 7.5
	15.0	GRAY [illegible] SANDY [illegible] FRACTURED [illegible]	[illegible]	[illegible]	100% F/L
	25.0	MATERIAL SUBSTANTIALLY SAND, FROM CUTTINGS	0.0		DRILLED [illegible] TO 31.0 W/CALIFORNIA BIT LANDED [illegible] PIPE AT 31.0
	31.0	SANDSTONE, [illegible] GRAY, [illegible] SILTY SAND [illegible]	[illegible]	3	
6172.2	37.7	BADLY WEATHERED [illegible] SHALE FRACTURED	100%		TOP OF IDENTIFIABLE [illegible] LOCATION
			40%	4	ABOVE [illegible] LANDED AT 46.6
	45.0			5	100% FL TO 41.0'

DRILLING LOG (continuation)

ALBUQUERQUE DIST.

Elevation	Depth	Classification of materials (description)	% Core recovery	Box or sample no.	Remarks
6164.9	45.0	BLUE SANDY SHALE VERY BADLY FRACTURED	100%	5	FL. 20% 44.0 - 49.6
	49.6	BLUE SANDY SHALE SILTY, BADLY FRACTURED	[illegible]	6	
			100%	7	
			100%		
6149.7	60.7	GRAY MED. HARD SS.	90%	8	
6144.3	65.6	HARD, BLUE SANDY SHALE	90%	9	HOLE CAVING ADDED 4.5' [illegible] PIPE LANDED TIP @ 45.1
					@65.6 SET PACKER @ 49.0, 5 PSI [illegible] 10 PSI 5.7 [illegible]
		HARD, BLUE SANDY SHALE STREAKED WITH WHITE SS.	95%	10	SET PACKER 57.9 5 PSI 0.9 GPM 10 PSI 1.1 GPM 15 PSI 1.4 GPM 20 PSI 2.0 GPM
6136.0	73.9	WHITE SS.			
	74.8	BLUE SHALE, FRACTURED		11	
	76.4	WHITE SS.	95%		
	76.8	BLUE [illegible]			
	79.4	BLUE SHALE		12	
6120.7	80.2	[illegible]	40%		
		[illegible] SOFT, FEW AREAS CONGLOMERITIC		13	
			[illegible]		
	89.7		79%	14	
		BROWN SANDY SHALE	0.0		
	92.4	MED. HARD BLUE SANDY SHALE	100%	15	
	[illegible]	HARD SANDY SHALE	[illegible]	16	
	[illegible]	MED. [illegible] SS.			

CORE FILE NO. 11

DEPARTMENT OF THE ARMY

DIVISION [illegible] CORPS

INSTALLATION ALBUQUERQUE DISTRICT

DRILLING LOG

LAT 760 E 1SP 956 T

ALBUQUERQUE DISTRICT

11

190.0

6 5/8" [illegible]

5145.7

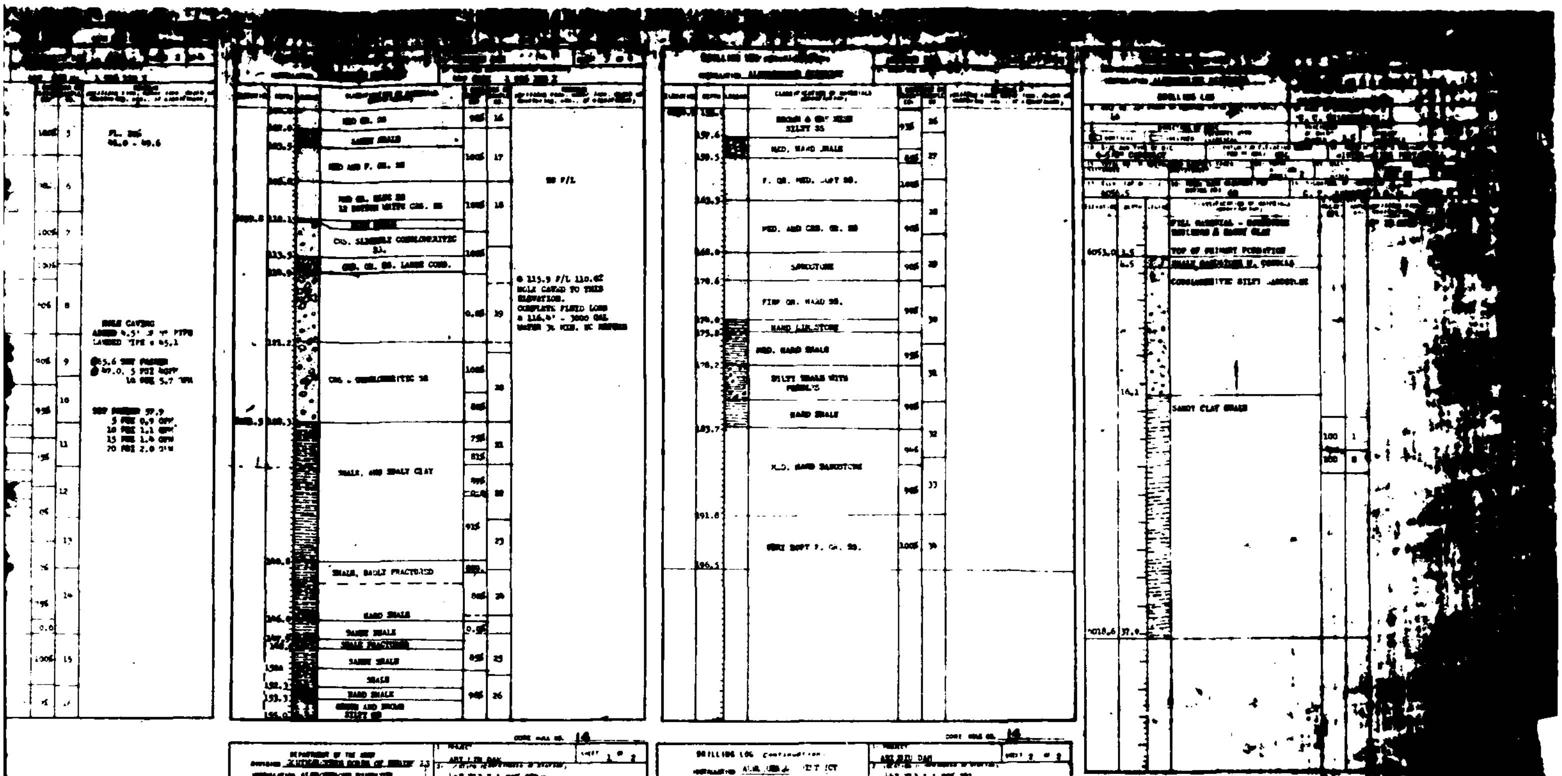
[illegible] 27 AUG 56

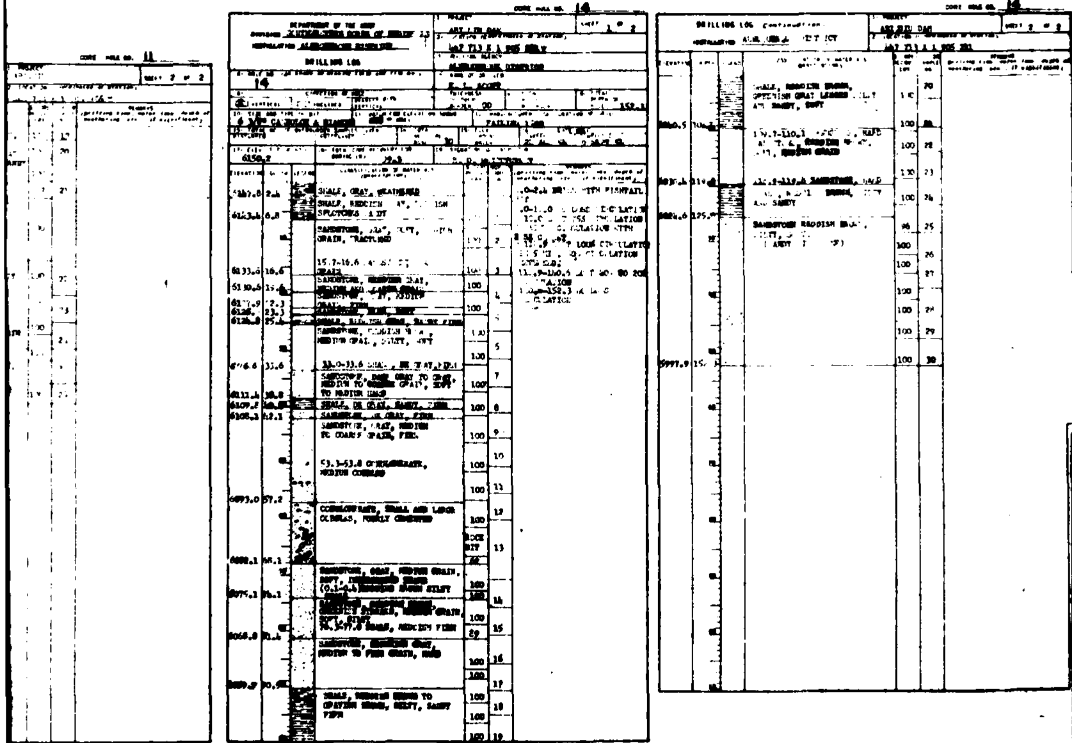
Elevation	Depth	Classification of materials (description)	% Core recovery	Box or sample no.	Remarks
		OVERBURDEN, CLAY, SANDSTONE BOULDERS, GRAY SHALE			CORED [illegible] IN SHALE CORED [illegible]
6130.5	5.7	SANDSTONE, GRAY, FINE GRAIN, SOFT, BADLY FRACTURED	100		[illegible]
[illegible]	[illegible]	SHALE, DARK GRAY, FIRM, SANDY		1	[illegible] 24,262 GALLONS [illegible] AS PUMPED INTO [illegible] JOINT PLANE-
6133.1	[illegible]	SANDSTONE, REDDISH GRAY, SOFT, MEDIUM COARSE GRAIN, S[illegible]	[illegible]	2	NO PRESSURE [illegible] AND [illegible] WITHOUT FILLING
6127.3	17.9	SHALE, REDDISH BROWN, [illegible] SANDY	100	3	THE [illegible], PERIODIC [illegible] IN THE FACE [illegible]
6123.[illegible]	22.2	SANDSTONE, REDDISH [illegible] TO GRAY, SOFT, MEDIUM [illegible] COARSE GRAIN FRACTURES	100	4	[illegible] BETWEEN THE [illegible] AND [illegible] SURFACE WAS [illegible]. AFTER PUMPING, [illegible] WAS [illegible] SEALED WITH 7 SX [illegible] AND 1/3 BAG [illegible]
			100	5	
			100	6	
		[illegible]	100	7	
		SANDSTONE, REDDISH [illegible] GRAY, MED UP TO COARSE GRAIN [illegible]	[illegible]		SI[illegible] LOGS [illegible] LOST 50% [illegible]
			[illegible]		
			100		FLUID [illegible] 29 AUG 56 [illegible] 5064.5
		[illegible] SOFT, [illegible]	71		
		SANDST[illegible] PEBBL[illegible]	[illegible]	11	
		[illegible] SOFT, LARGE [illegible]	71		
			1.0		
		SHALE, [illegible] SPLOTCHES [illegible] SILTY		12	
			[illegible]	13	
			100	14	
		SANDSTONE, [illegible] MED. GRAY, SOFT, [illegible]	[illegible]	15	
			[illegible]	16	
		SHALE, GRAY [illegible], SOFT, [illegible]	100	17	
			[illegible]	[illegible]	
			1.0	[illegible]	

CORE FILE NO. 11

DRILLING LOG (continuation)

Elevation	Depth	Classification of materials (description)	% Core recovery	Box or sample no.	Remarks
		[illegible] SANDSTONE, GRAY, COARSE GRAIN, FIRM SHALE REDDISH BROWN, GREENISH GRAY STREAKS, SOFT, SILTY AND SANDY	[illegible]	[illegible]	
		[illegible] CONGLOMERATE			
6020.9	126.3	SANDSTONE, REDDISH [illegible], MEDIUM - COARSE GRAIN, SILTY MEDIUM SOFT	[illegible]		
		SANDSTONE, GRAY, MEDIUM GRAIN SILTY, HARD	100		
		[illegible] SHALE CONGLOMERATE, GREENISH GRAY, HARD			
5997.6	147.6				
5995.2	150.0	SHALE, REDDISH BROWN, SOFT			





NOTE:
FOR GEOLOGIC NOTES AND LEGEND SEE PLATE 10

US ARMY ENGINEER DISTRICT, ALBUQUERQUE
CORPS OF ENGINEERS
ALBUQUERQUE, NEW MEXICO

RIO GRANDE WATERSHED

ABIQUIU DAM
EMBANKMENT & SPILLWAY

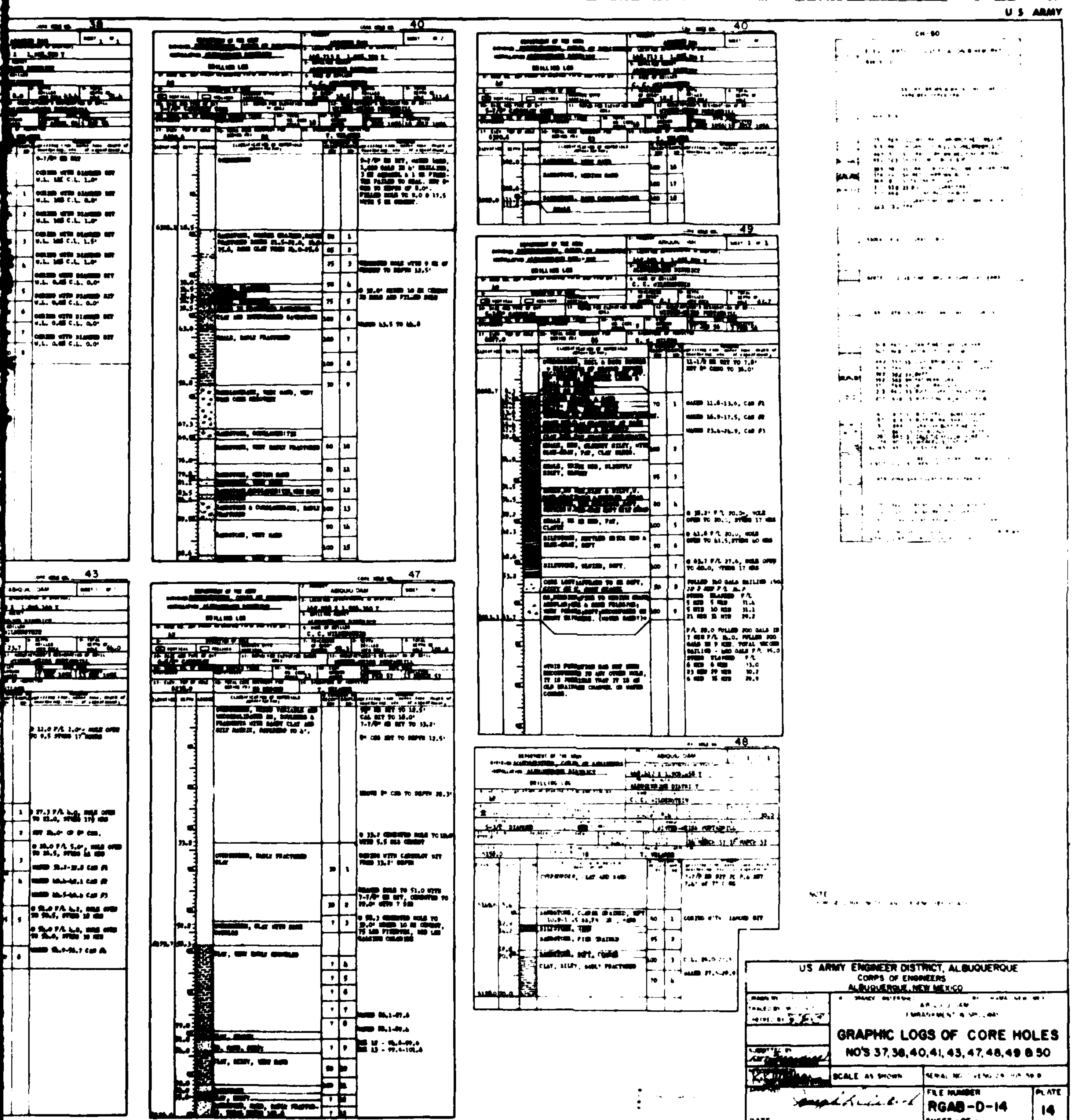
GRAPHIC LOGS OF CORE HOLES
NO'S 6,11,14,&16

SCALE: AS SHOWN

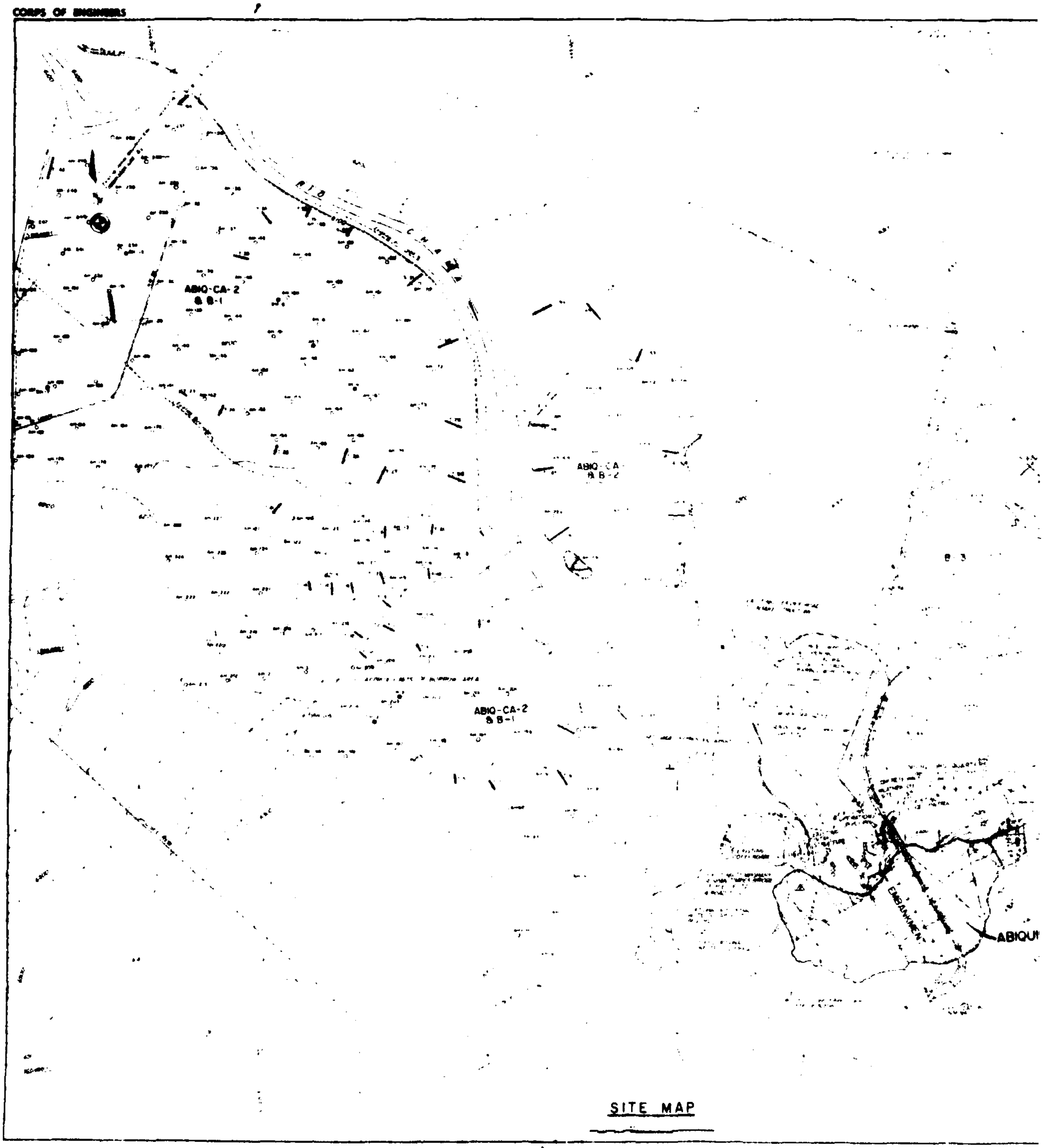
FILE NUMBER
RGAB-D-[illegible]

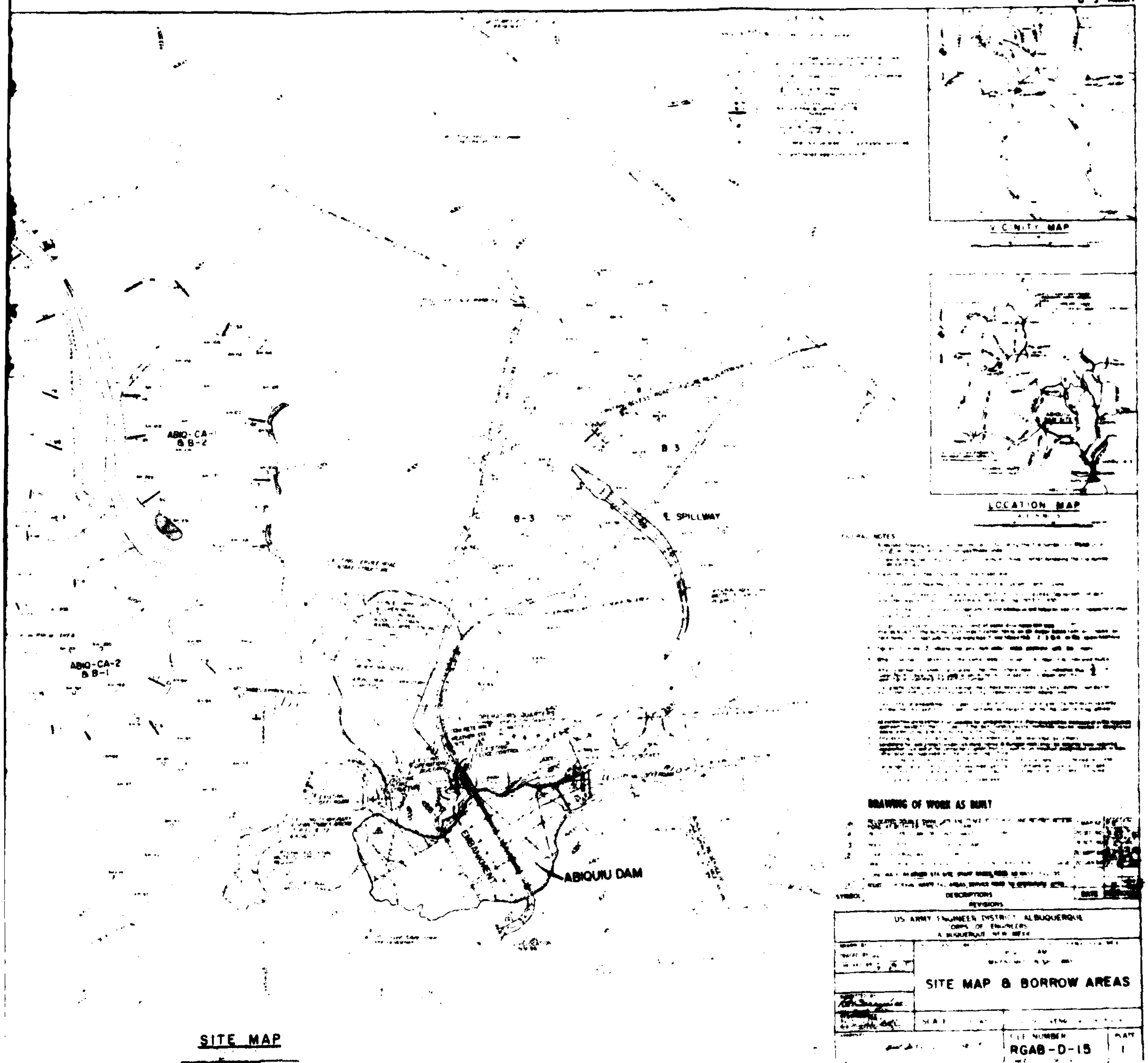
13

[illegible]

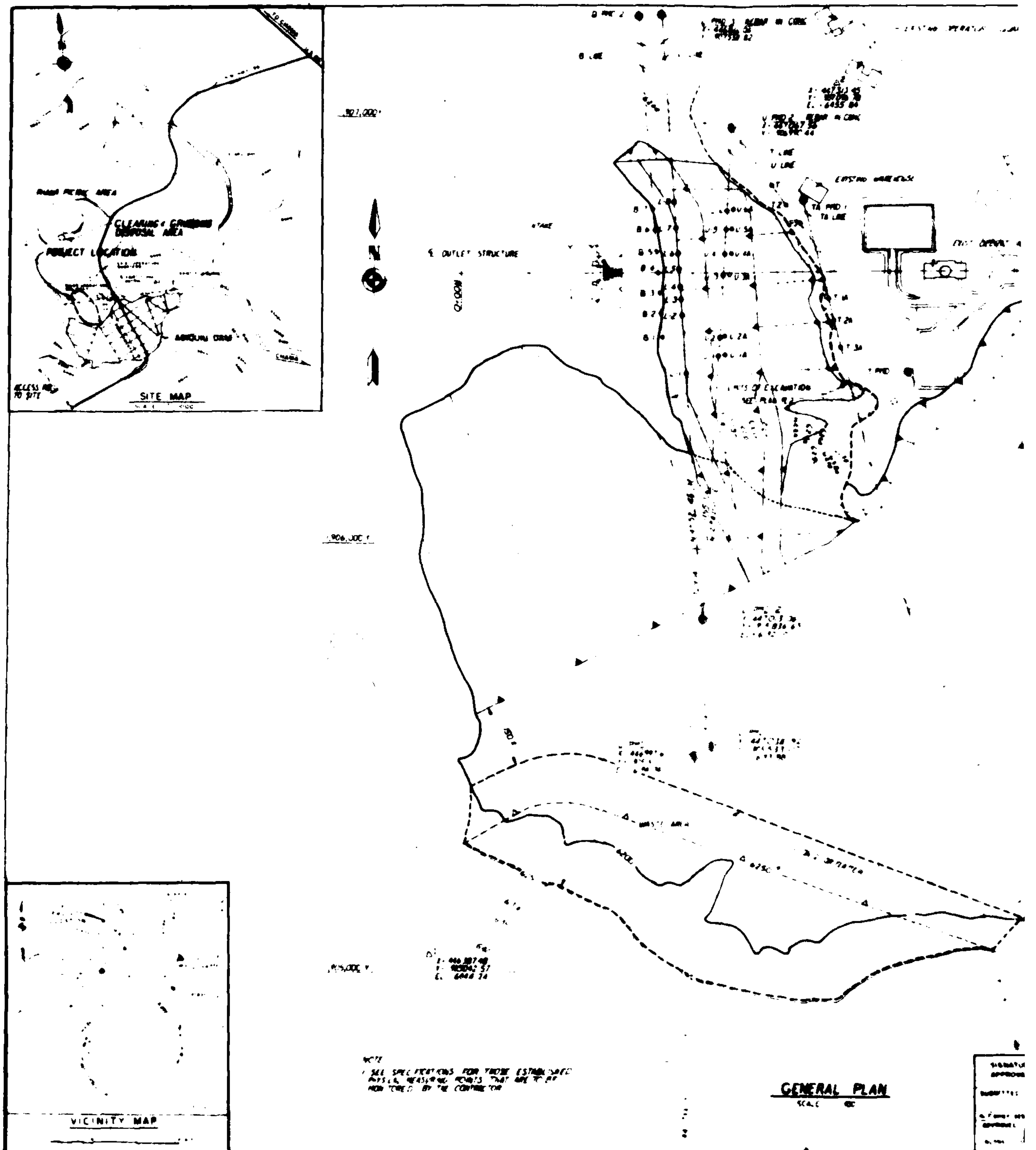

U S ARMY
38
40
43
47
48
49
US ARMY ENGINEER DISTRICT, ALBUQUERQUE
CORPS OF ENGINEERS
ALBUQUERQUE, NEW MEXICO
GRAPHIC LOGS OF CORE HOLES
NO'S 37,38,40,41,43,47,48,49 & 50
SCALE AS SHOWN
FILE NUMBER
RGAB-D-14
PLATE
14
DATE

CORPS OF ENGINEERS

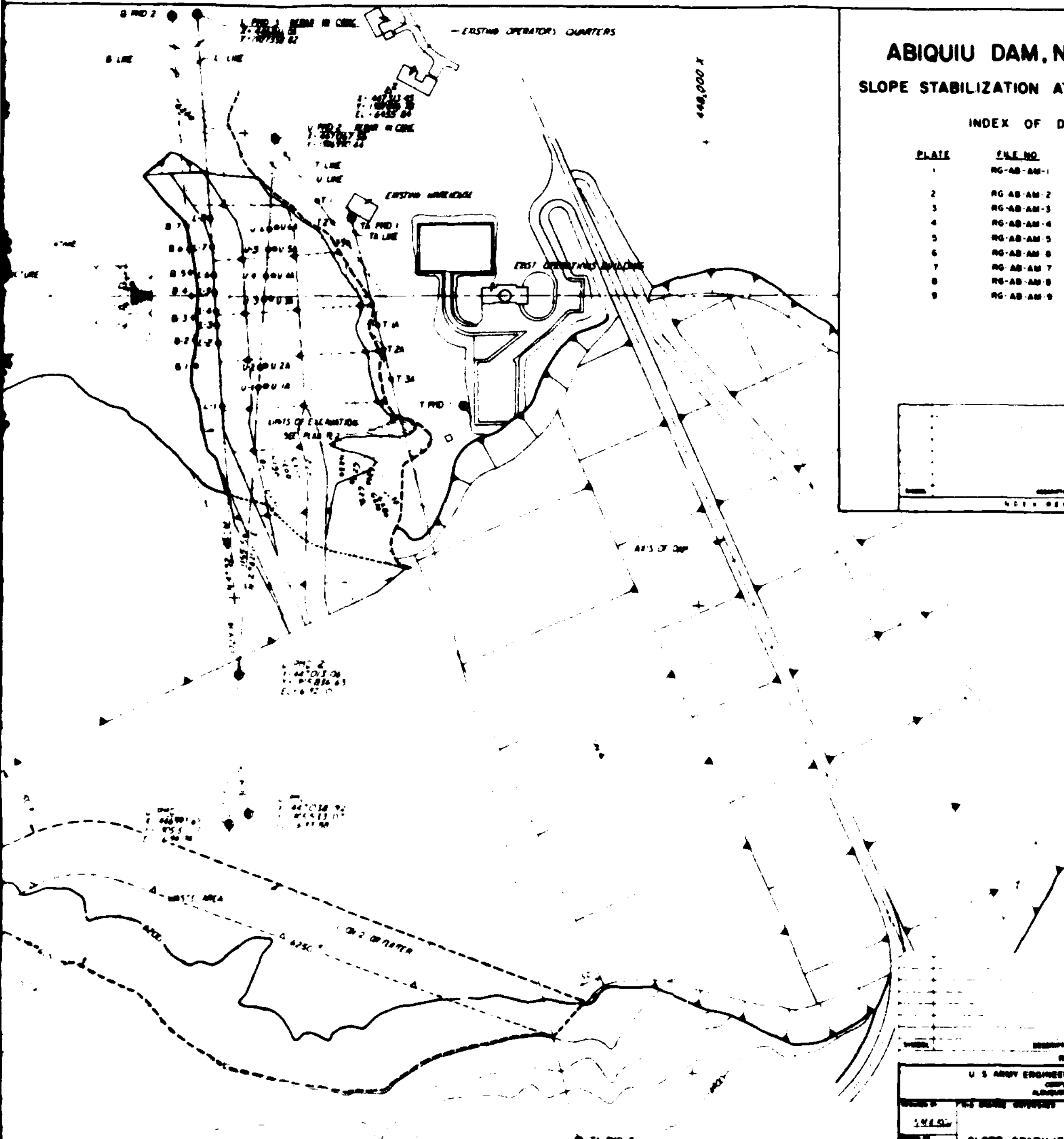



U S ARMY
VICINITY MAP
LOCATION MAP
ABIQ-CA-1
& B-2
B-3
B-3
SPILLWAY
ABIQ-CA-2
& B-1
EMBANKMENT
ABIQUIU DAM
DRAWING OF WORK AS BUILT
SYMBOL
DESCRIPTIONS
REVISIONS
SITE MAP & BORROW AREAS
RGAB-D-15
SITE MAP

2



VALUE ENGINEERING PROPOSALS MEAN



GENERAL PLAN

ABIQUIU DAM, NEW MEXICO

SLOPE STABILIZATION AT INTAKE STRUCTURE

INDEX OF DRAWINGS

PLATE	FILE NO	TITLE
1	RG-AB-AM-1	GENERAL PLAN, SITE MAP & INDEX
2	RG-AB-AM-2	EXCAVATION PLAN & SECTIONS
3	RG-AB-AM-3	SECTIONS 1,2 & 3
4	RG-AB-AM-4	SECTIONS 4,5 & 6
5	RG-AB-AM-5	SECTIONS 7,8 & 9
6	RG-AB-AM-6	SECTIONS 10,11 & 12
7	RG-AB-AM-7	SECTIONS 13,14 & 15
8	RG-AB-AM-8	SECTIONS 16 & 17
9	RG-AB-AM-9	GEOLOGIC SECTION & GRAPHIC LOGS

REVISIONS

SIGNATURES AFFIXED BELOW INDICATE OFFICIAL RECOMMENDATION AND APPROVAL OF ALL DRAWINGS IN THIS SET AS INDEXED ON THIS SHEET

SUBMITTED

APPROVED

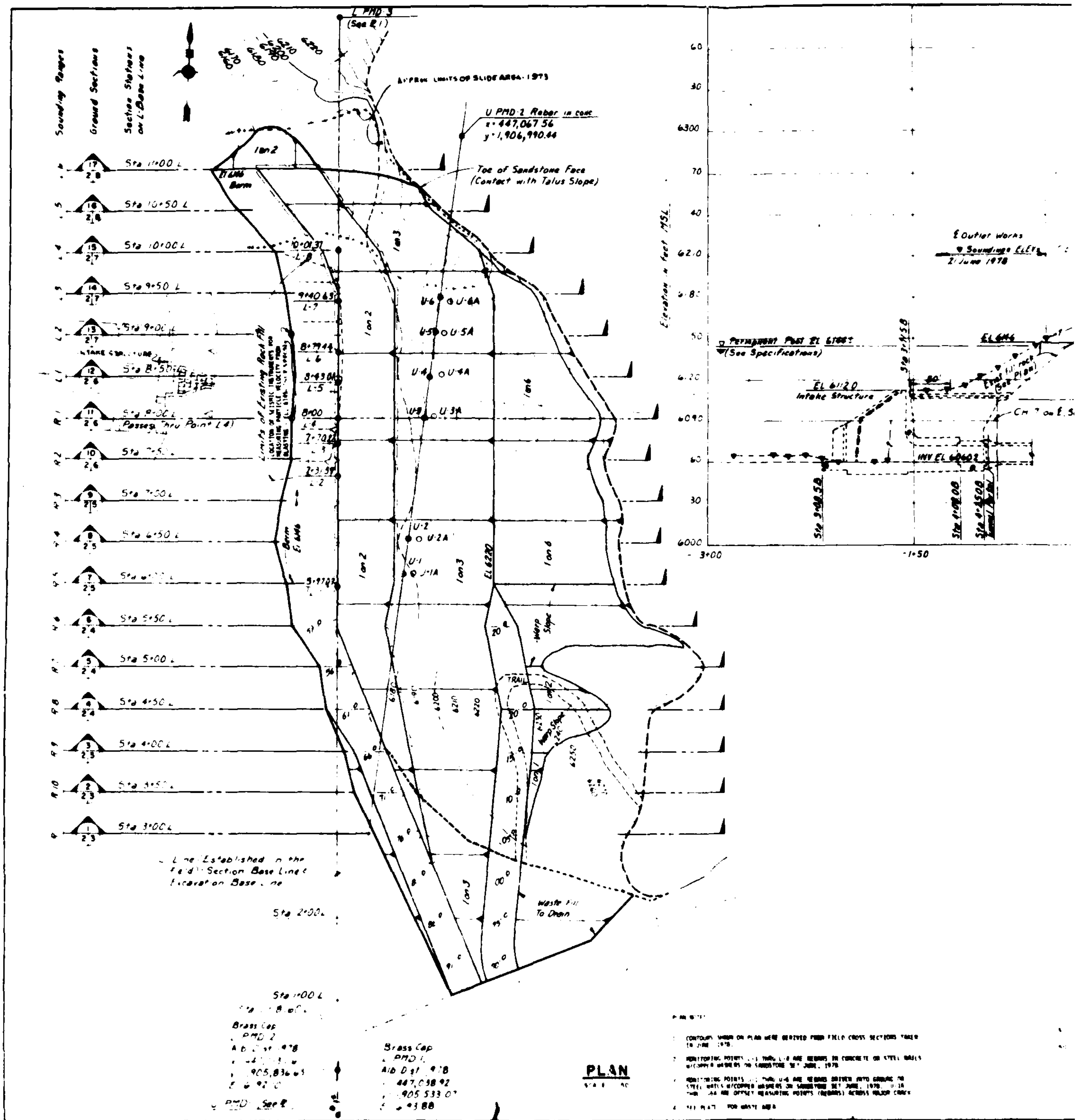
U. S. ARMY ENGINEER DISTRICT ALBUQUERQUE
CORPS OF ENGINEERS
ALBUQUERQUE, NEW MEXICO

ABIQUIU DAM
SLOPE STABILIZATION AT INTAKE STRUCTURE
GENERAL PLAN, SITE MAP & INDEX

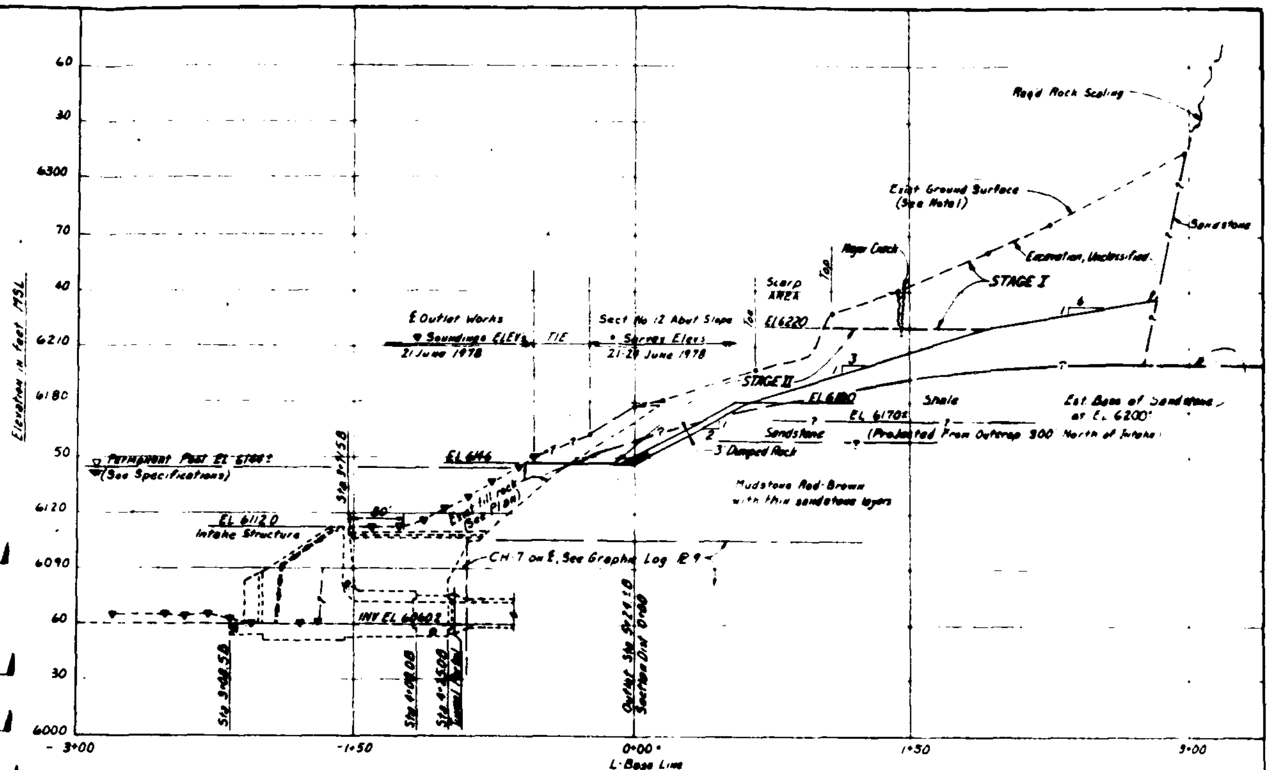
DACW 47-79-B 0016

PLATE 1

FILE NUMBER RG-AB-AM-1



Sounding Ranges
Ground Sections
Section Stations on ℄ Base Line
APPROX. LIMITS OF SLIDE AREA - 1973
U PMD 2 Rebar in conc
x = 447,067.56
y = 1,906,990.44
Toe of Sandstone Face (Contact with Talus Slope)
Sta 11+00 ℄
Sta 10+50 ℄
Sta 10+00 ℄
Sta 9+50 ℄
Sta 9+00 ℄
Sta 8+50 ℄
Sta 8+00 ℄
Passes Thru Point L4
Sta 6+50 ℄
Sta 5+50 ℄
Sta 5+00 ℄
Sta 4+50 ℄
Sta 4+00 ℄
Sta 3+00 ℄
Sta 2+00 ℄
Sta 1+00 ℄
1 on 2
1 on 3
1 on 6
EL 6220
Berm
Limits of Existing Rock Fill
Warp Slope
TRAIL
Waste Fill To Drain
U-6 U-6A
U-5 U-5A
U-4 U-4A
U-3 U-3A
U-2 U-2A
U-1 U-1A
9+40.63 L-7
8+79.44 L-6
8+43.04 L-5
8+00 L-4
Line Established in the Field - Section Base Line & Excavation Base Line
Brass Cap PMD 2
Brass Cap PMD 1
447,038.92
Elevation in feet MSL
6300
6200
6000
- 3+00
- 1+50
℄ Outlet Works
Soundings ELEVs. 21 June 1978
Permanent Post EL 6166
(See Specifications)
EL 6112.0 Intake Structure
INV EL 6060.2
Sta 3+48.50
Sta 1+98.00
PLAN

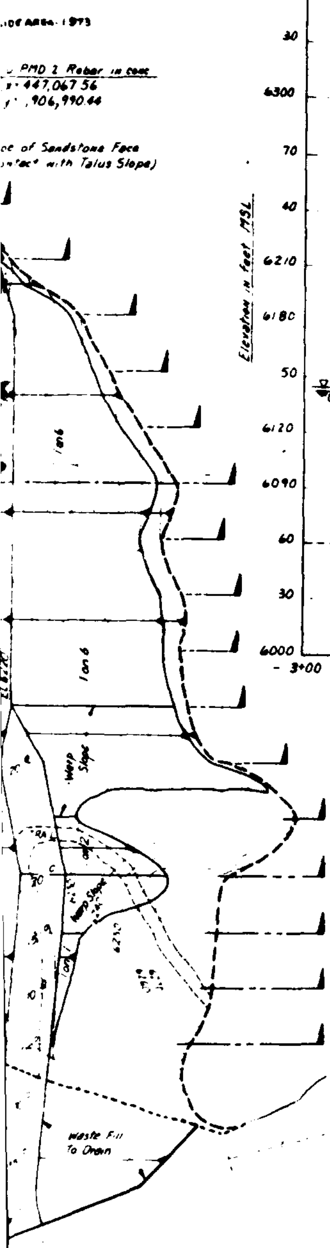


TYPICAL SECTION

SCALE 1"=30' Horiz & Vert

SECTION NOTES

1. NUMEROUS LARGE BOULDERS PROJECT ABOVE THE GROUND SURFACE THAT ARE NOT SHOWN ON SECTION.
2. ABOVE ELEVATION 6180 THE EXCAVATION SHALL GO TO GRADES SHOWN OR TOP OF ROCK AS DIRECTED BY CONTRACTING OFFICER
3. SEE PLAN, THIS PLATE, AND SECTIONS, PLATES 3 THROUGH 8 FOR VARYING ELEVATIONS AND SLOPE TRANSITIONS



PLAN

SCALE 1"=30'

PLAN NOTES

1. CONTOURS SHOWN ON PLAN WERE DERIVED FROM FIELD CROSS SECTIONS TAKEN IN JUNE, 1978.
2. MONITORING POINTS L-1 THRU L-8 ARE REBARS IN CONCRETE OR STEEL NAILS W/COPPER WASHERS ON SANDSTONE SET JUNE, 1978.
3. MONITORING POINTS U-1 THRU U-6 ARE REBARS DRIVEN INTO GROUND OR STEEL NAILS W/COPPER WASHERS ON SANDSTONE SET JUNE, 1978. U-1A THRU U-6A ARE OFFSET MEASURING POINTS (REBARS) ACROSS MAJOR CRACK.
4. SEE PLATE 1 FOR WASTE AREA.

SYMBOL	DESCRIPTIONS	DATE	APPROVAL

REVISIONS

U S ARMY ENGINEER DISTRICT ALBUQUERQUE
CORPS OF ENGINEERS
ALBUQUERQUE NEW MEXICO

RIO GRANDE WATERSHED — RIO CHAMA, NEW MEXICO

DESIGNED BY: NMRPG
DRAWN BY: TAC
CHECKED BY: JW

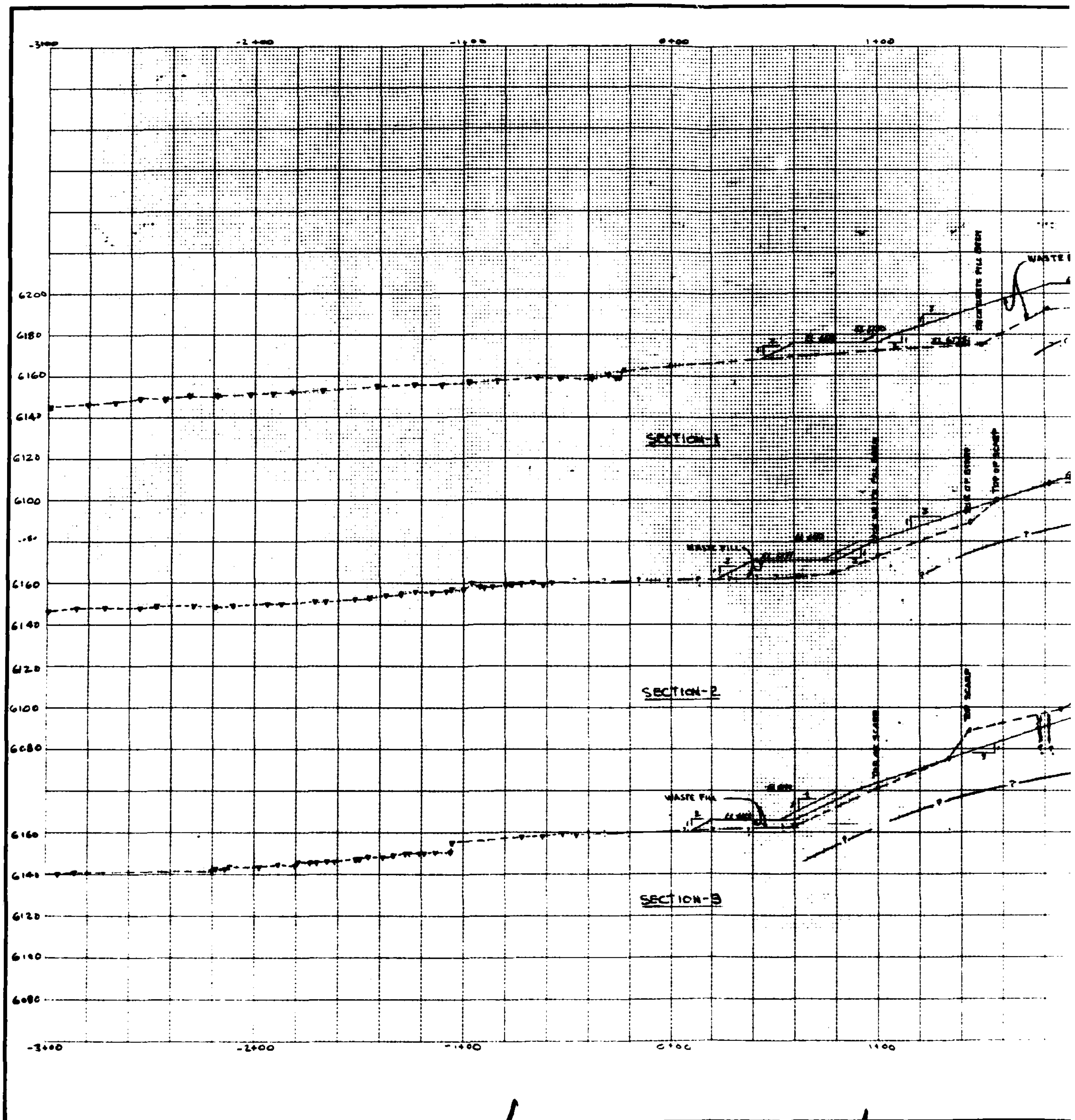
ABIQUIU DAM
SLOPE STABILIZATION AT INTAKE STRUCTURE

EXCAVATION PLAN & SECTION

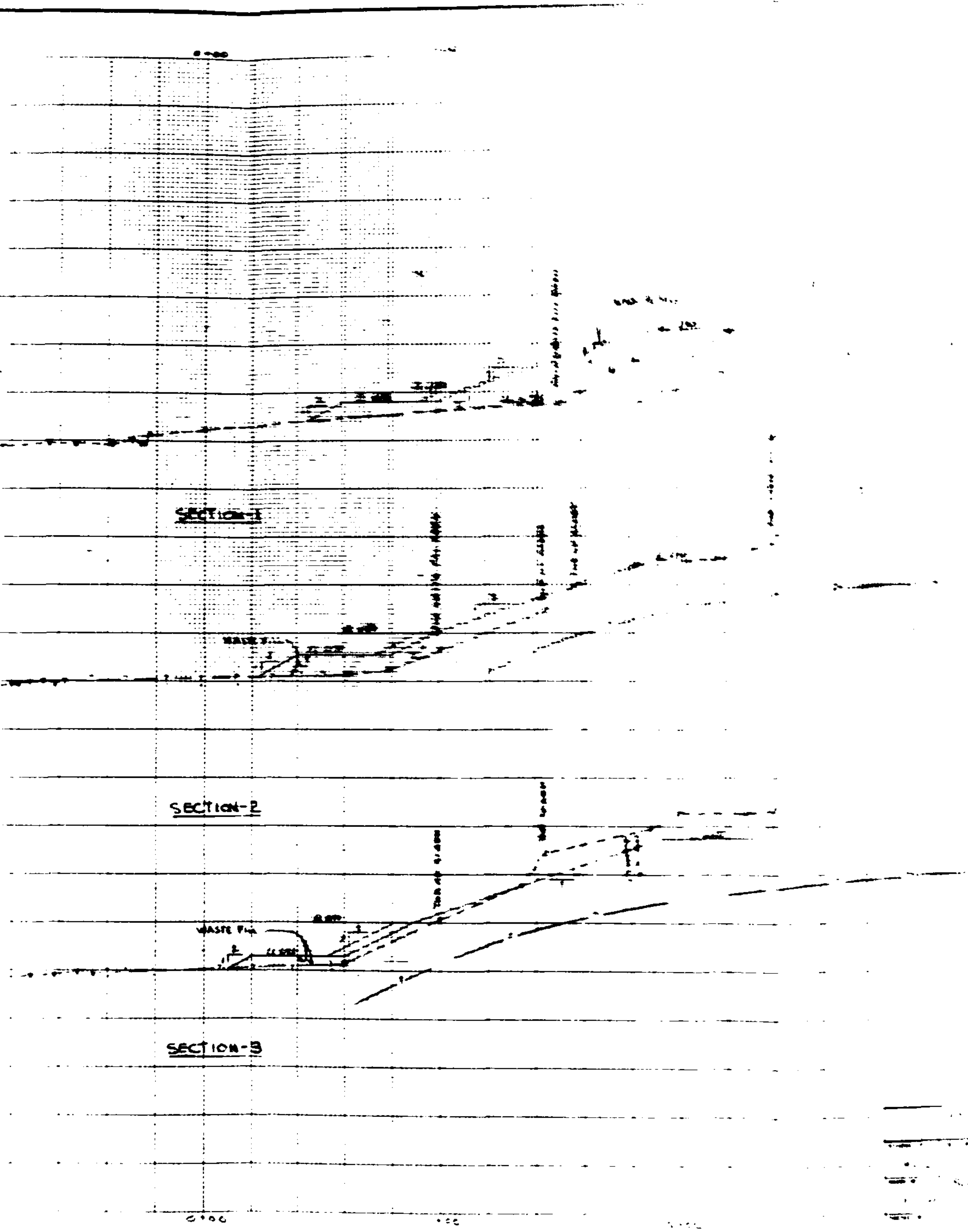
CHIEF GEOTECHNICAL SECTION
DATE JULY 1978

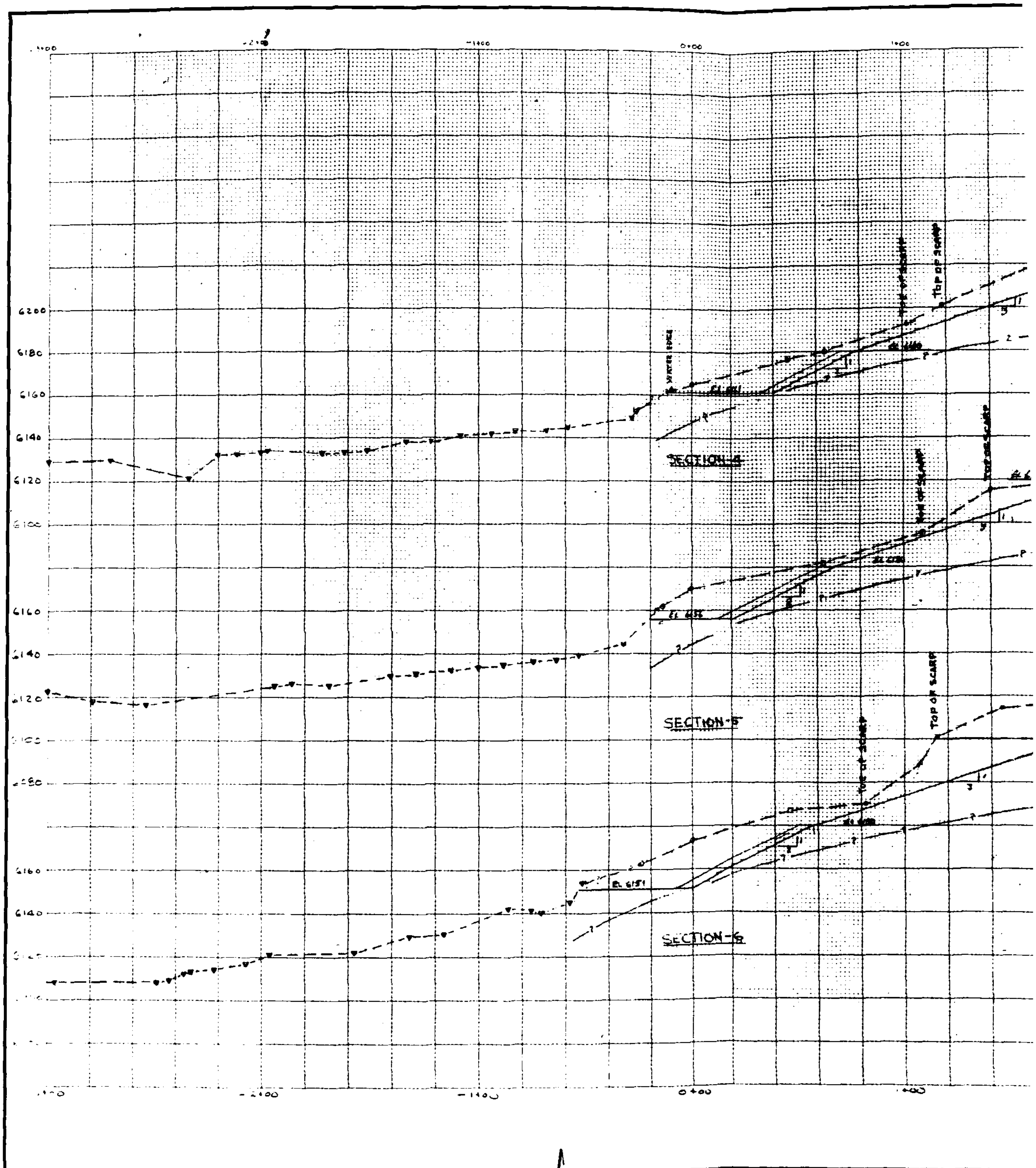
DACW 47-78-B-0016
FILE NUMBER RG-AB-AM-2
PLATE 2

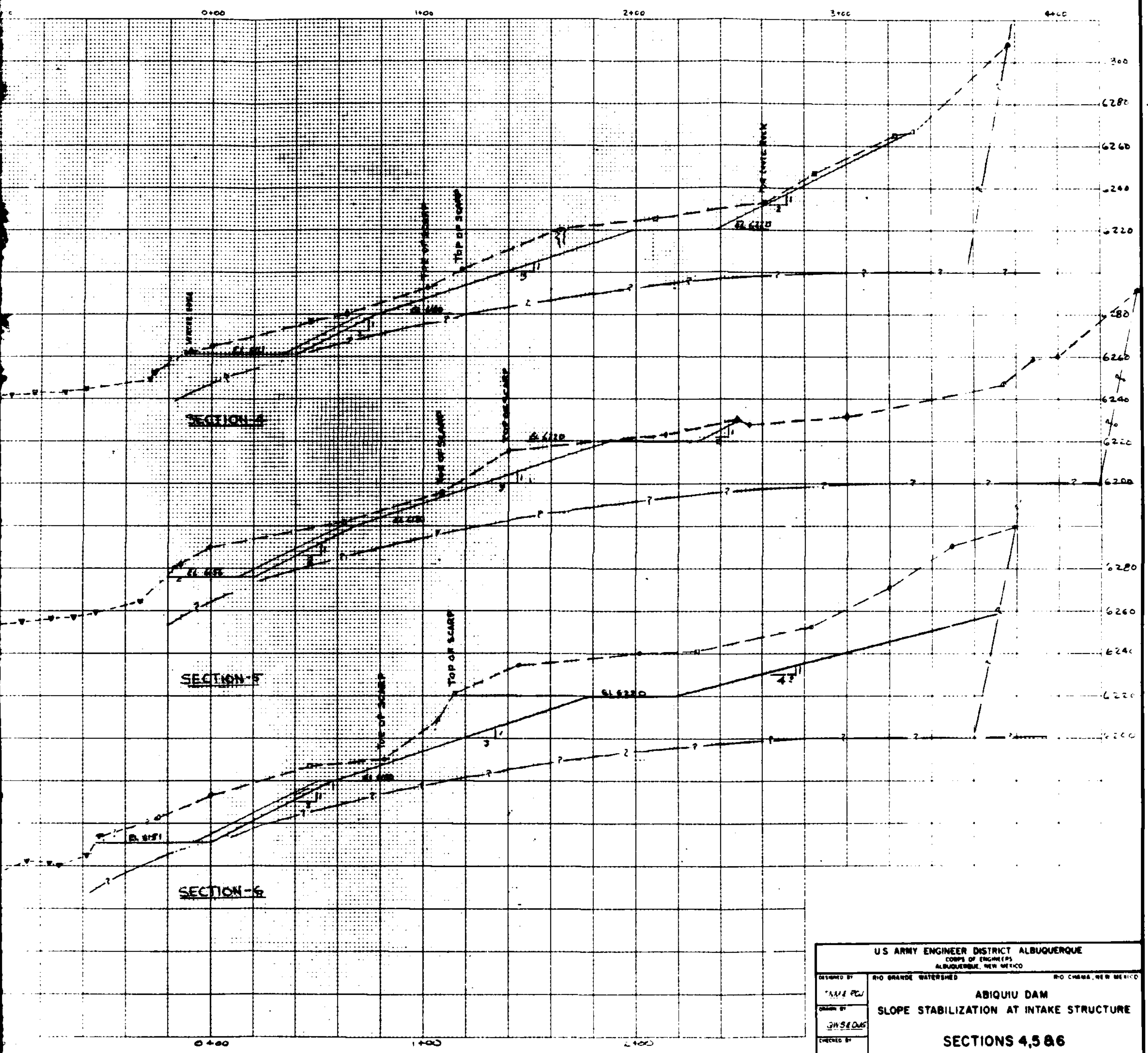
VALUE ENGINEERING PROPOSALS MEAN HIGHER PROFITS



SECTION-1
SECTION-2
SECTION-3
WASTE FILL
6200
6180
6160
6120
6100
6140
6080
-3+00
-2+00
-1+00
0+00
1+00


SECTION-1
WASTE FILL
SECTION-2
WASTE FILL
SECTION-3
0+00


0+00
6200
6180
6160
6140
6120
6100
SECTION-4
SECTION-5
SECTION-6
TOP OF SCARP
EL 6151



US ARMY ENGINEER DISTRICT ALBUQUERQUE
CORPS OF ENGINEERS
ALBUQUERQUE, NEW MEXICO

RIO GRANDE WATERSHED | RIO CHAMA, NEW MEXICO

ABIQUIU DAM
SLOPE STABILIZATION AT INTAKE STRUCTURE

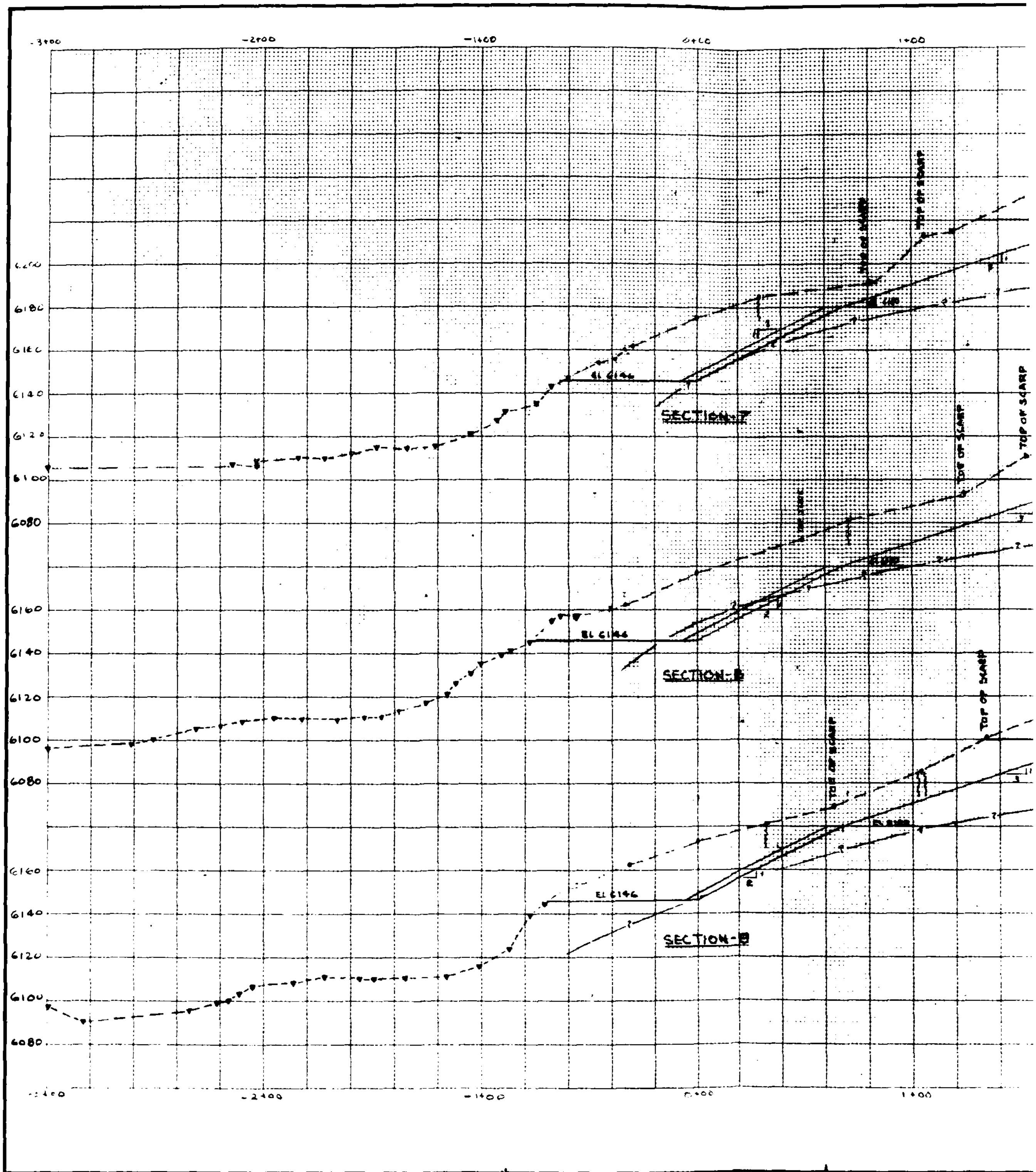
SECTIONS 4,5 & 6

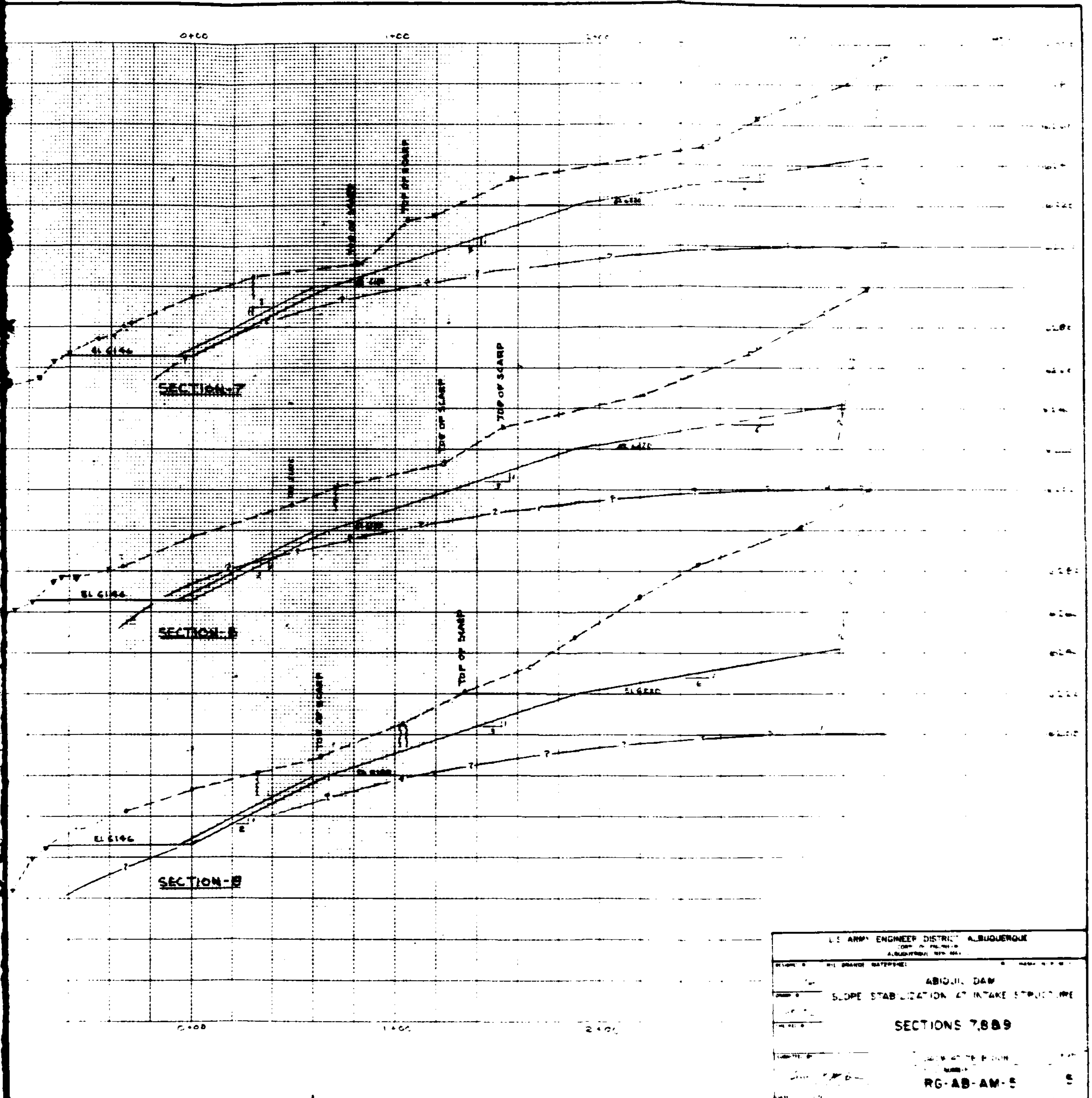
DESIGNED BY / DRAWN BY / CHECKED BY / SUBMITTED BY

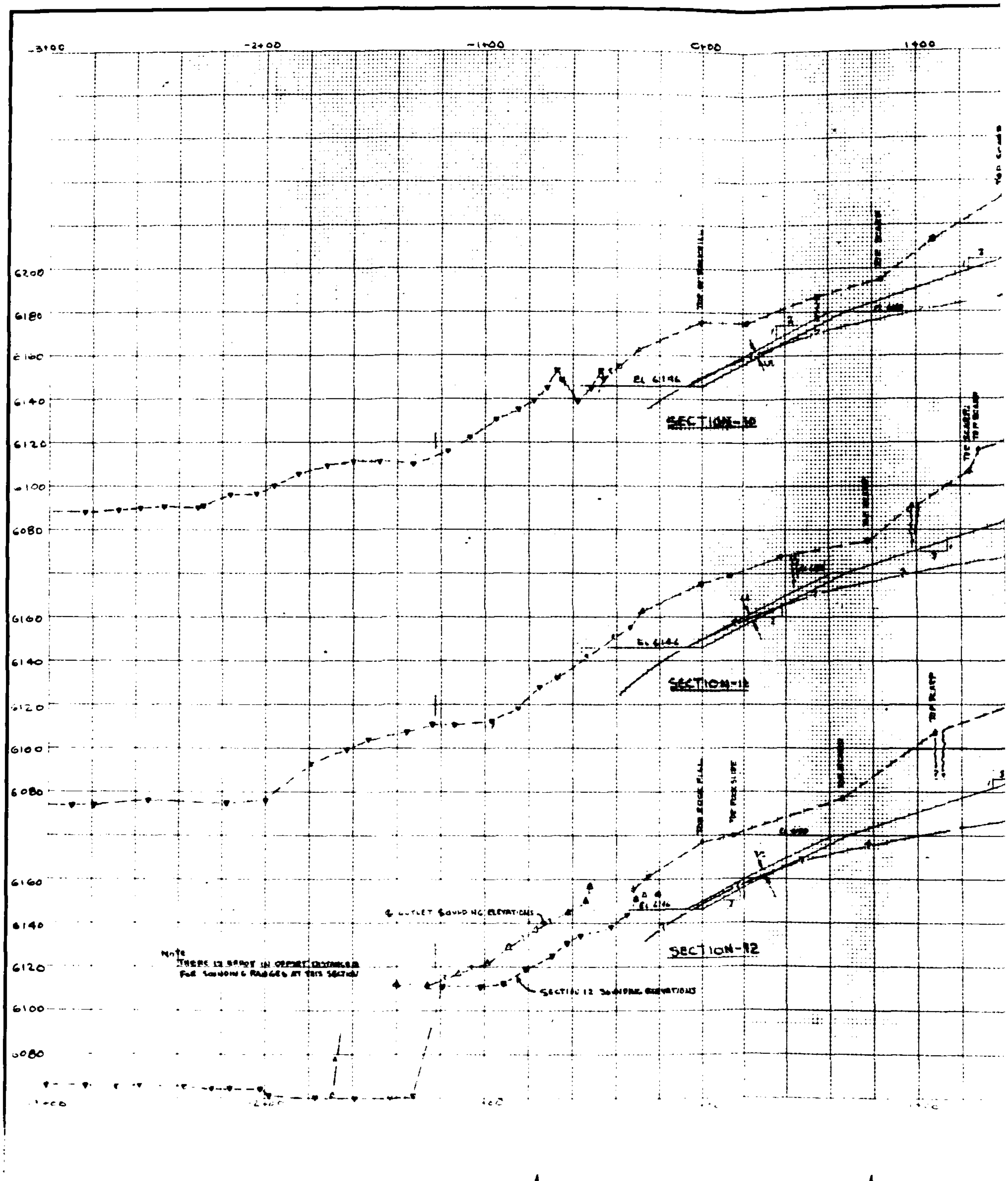
DACW 47-78-B-0016

FILE NUMBER
RG-AB-AM-4

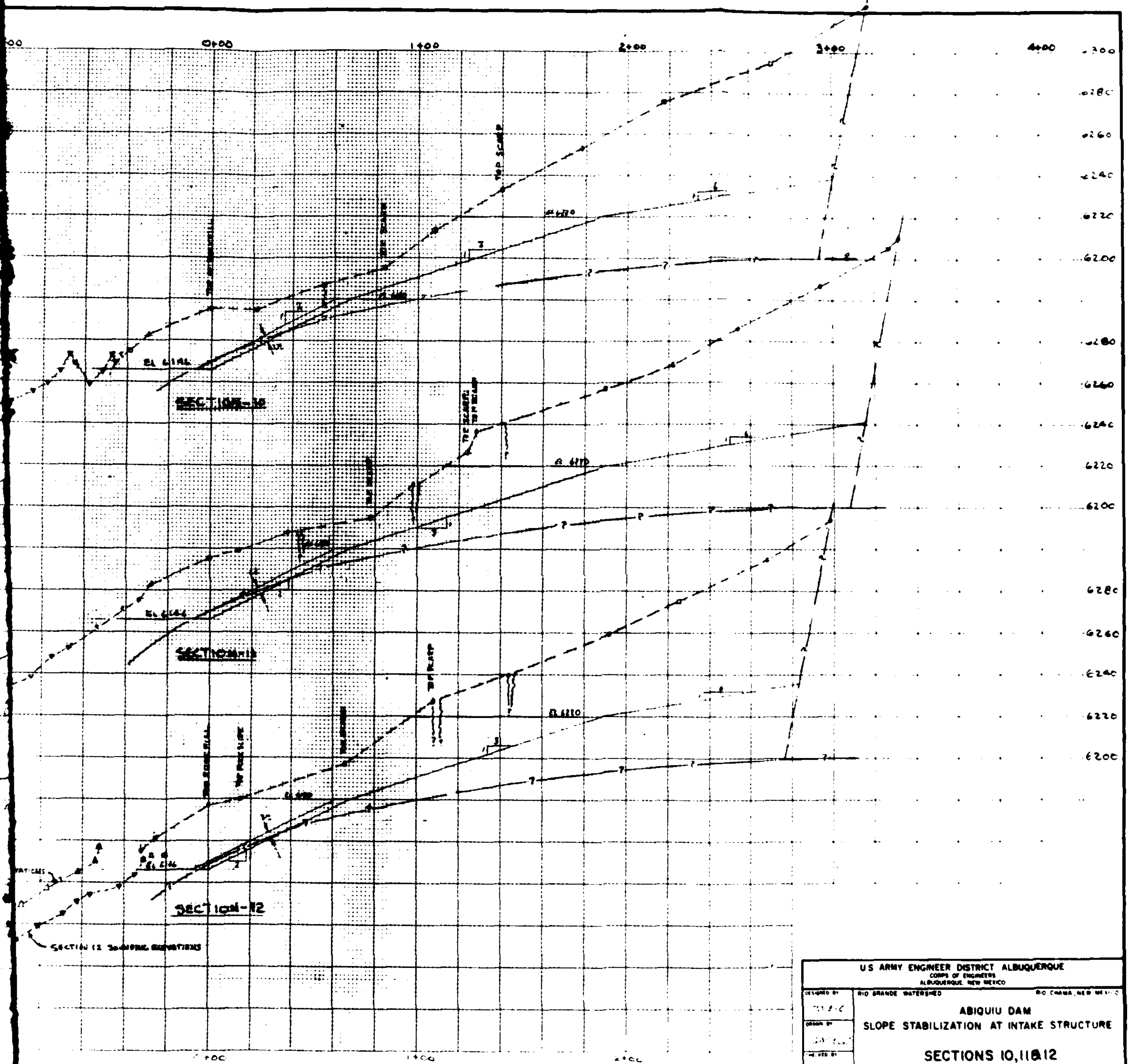
PLATE 4


-2+00
-1+00
0+00
1+00
6180
6140
6080
6160
6140
6120
6100
6080
6160
6140
6120
6100
6080
EL 6146
TOP OF SCARP
SECTION
EL 6146
TOP OF SCARP
SECTION
EL 6146
TOP OF SCARP
SECTION


0+00
1+00
SECTION-7
SECTION-8
SECTION-9
TOP OF SCARP
EL 6146
U.S. ARMY ENGINEER DISTRICT, ALBUQUERQUE
ABIQUIU DAM
SLOPE STABILIZATION AT INTAKE STRUCTURE
SECTIONS 7,8&9
RG-AB-AM-5



-3+00
-2+00
-1+00
0+00
1+00
6200
6180
6160
6140
6120
6100
6080
EL 6146
SECTION-10
SECTION-11
SECTION-12
℄ OUTLET SOUNDING ELEVATIONS
SECTION 12 SOUNDING ELEVATIONS
Note
THERE IS ERROR IN OFFSET DISTANCES
FOR SOUNDING RANGES AT THIS SECTION



US ARMY ENGINEER DISTRICT ALBUQUERQUE
CORPS OF ENGINEERS
ALBUQUERQUE, NEW MEXICO

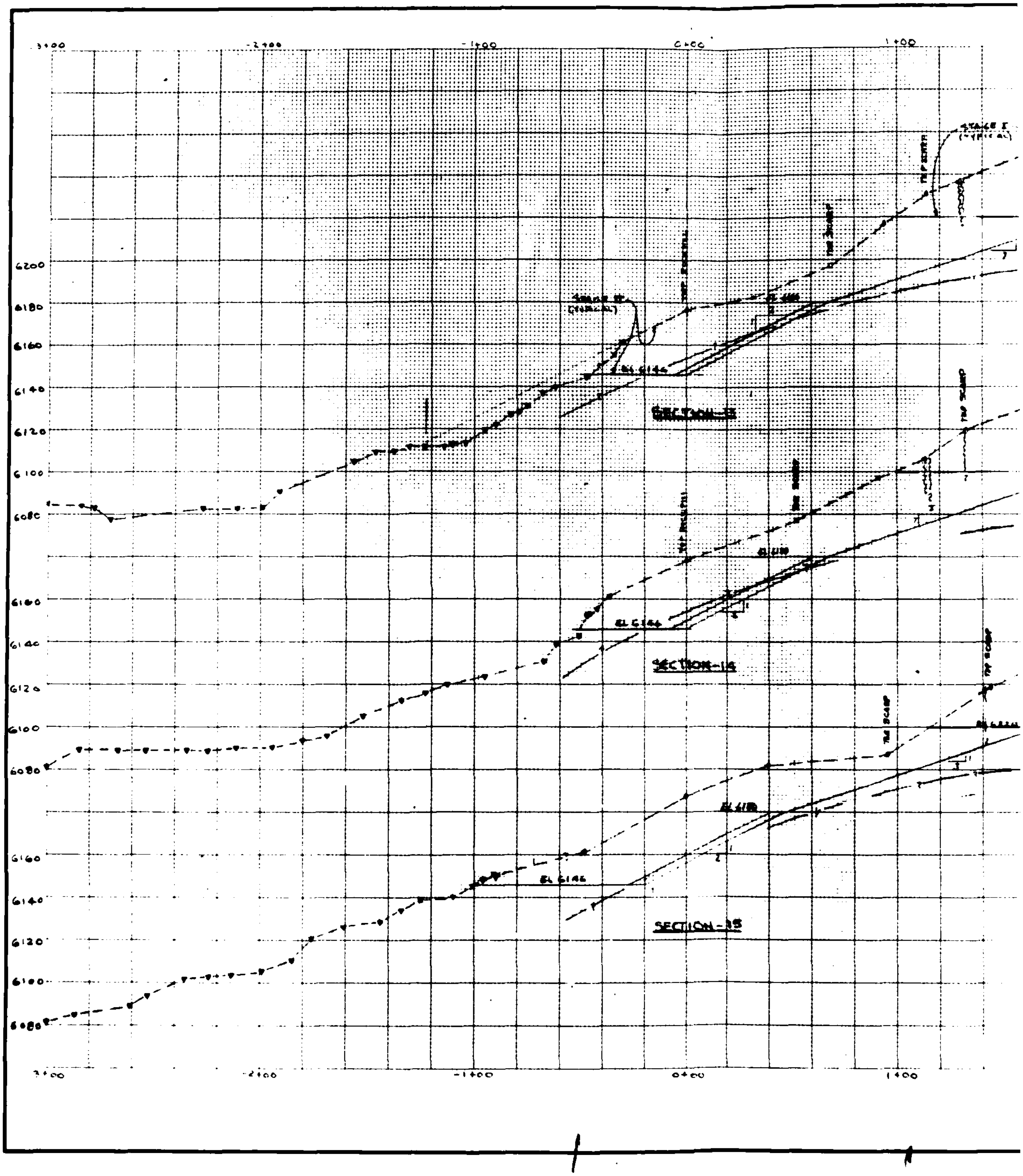
RIO GRANDE WATERSHED — RIO CHAMA, NEW MEXICO

ABIQUIU DAM
SLOPE STABILIZATION AT INTAKE STRUCTURE

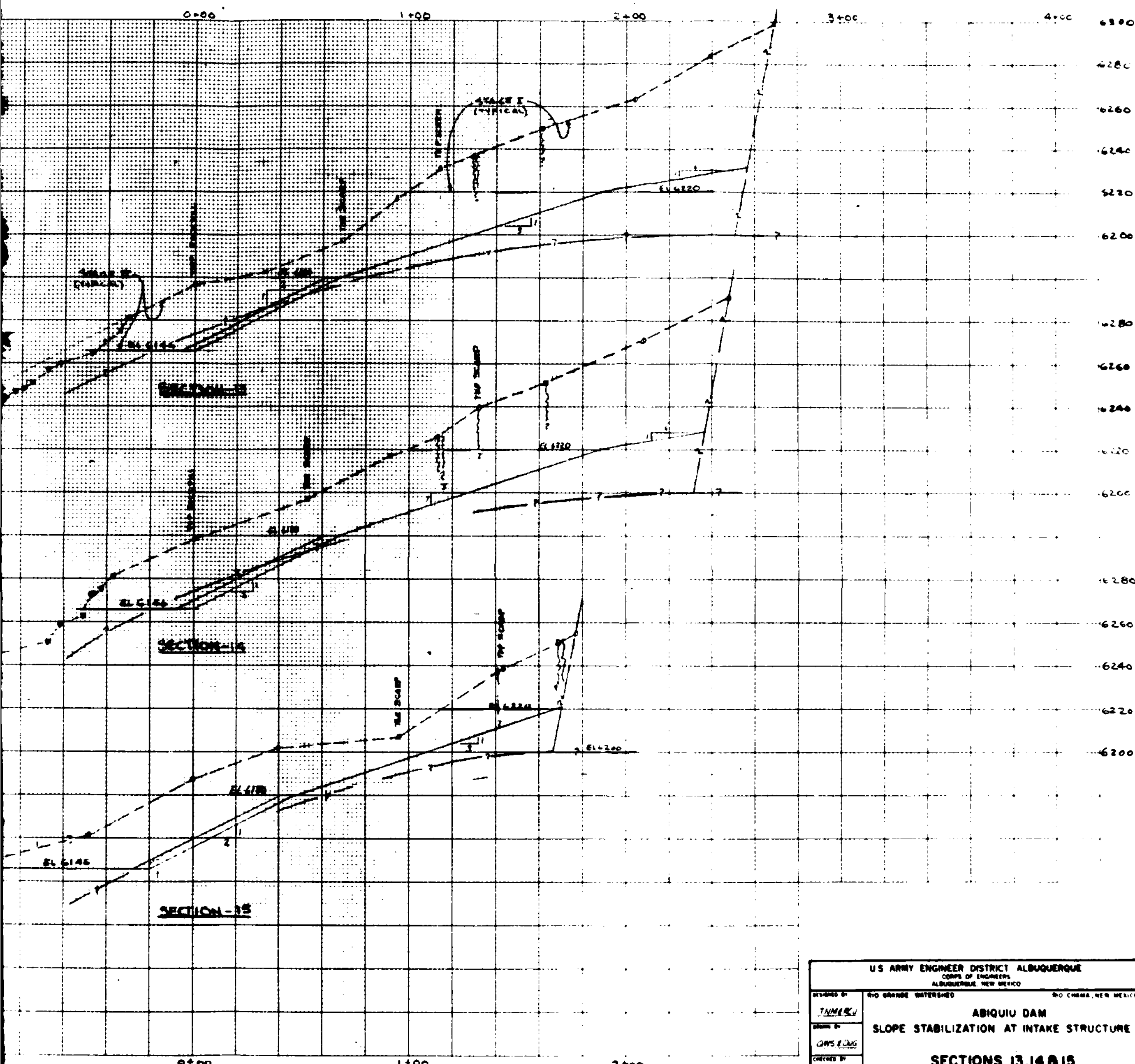
SECTIONS 10,11&12

RG-AB-

2



SECTION-13
SECTION-14
SECTION-15
EL 6146
TOP SCARP
TOP BACKFILL
STAGE I (TYPICAL)
STAGE II (TYPICAL)
6200
6180
6160
6140
6120
6100
6080
0+00
1+00
-1+00
-2+00
-3+00



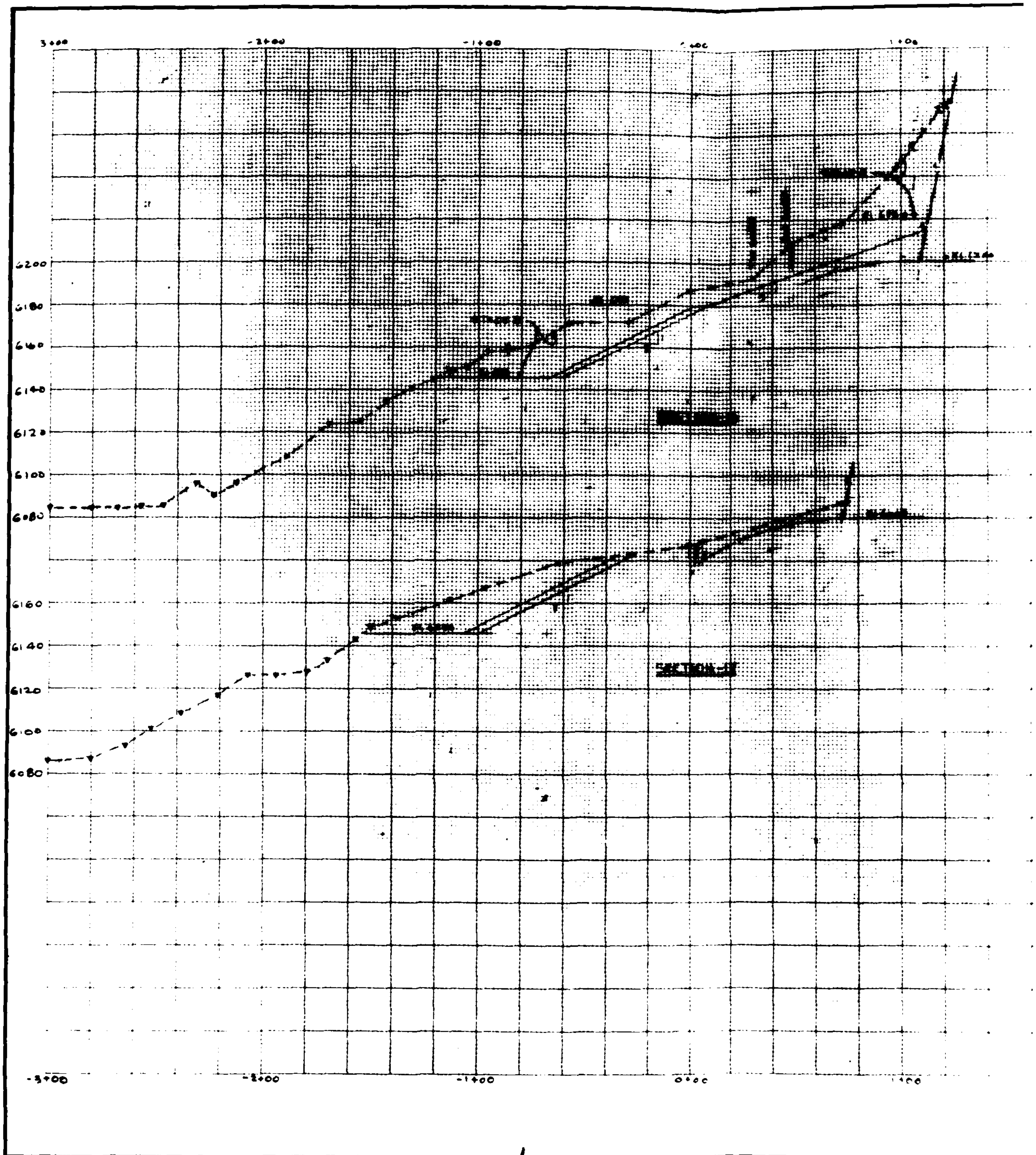
US ARMY ENGINEER DISTRICT ALBUQUERQUE
CORPS OF ENGINEERS
ALBUQUERQUE, NEW MEXICO

RIO GRANDE WATERSHED — RIO CHAMA, NEW MEXICO

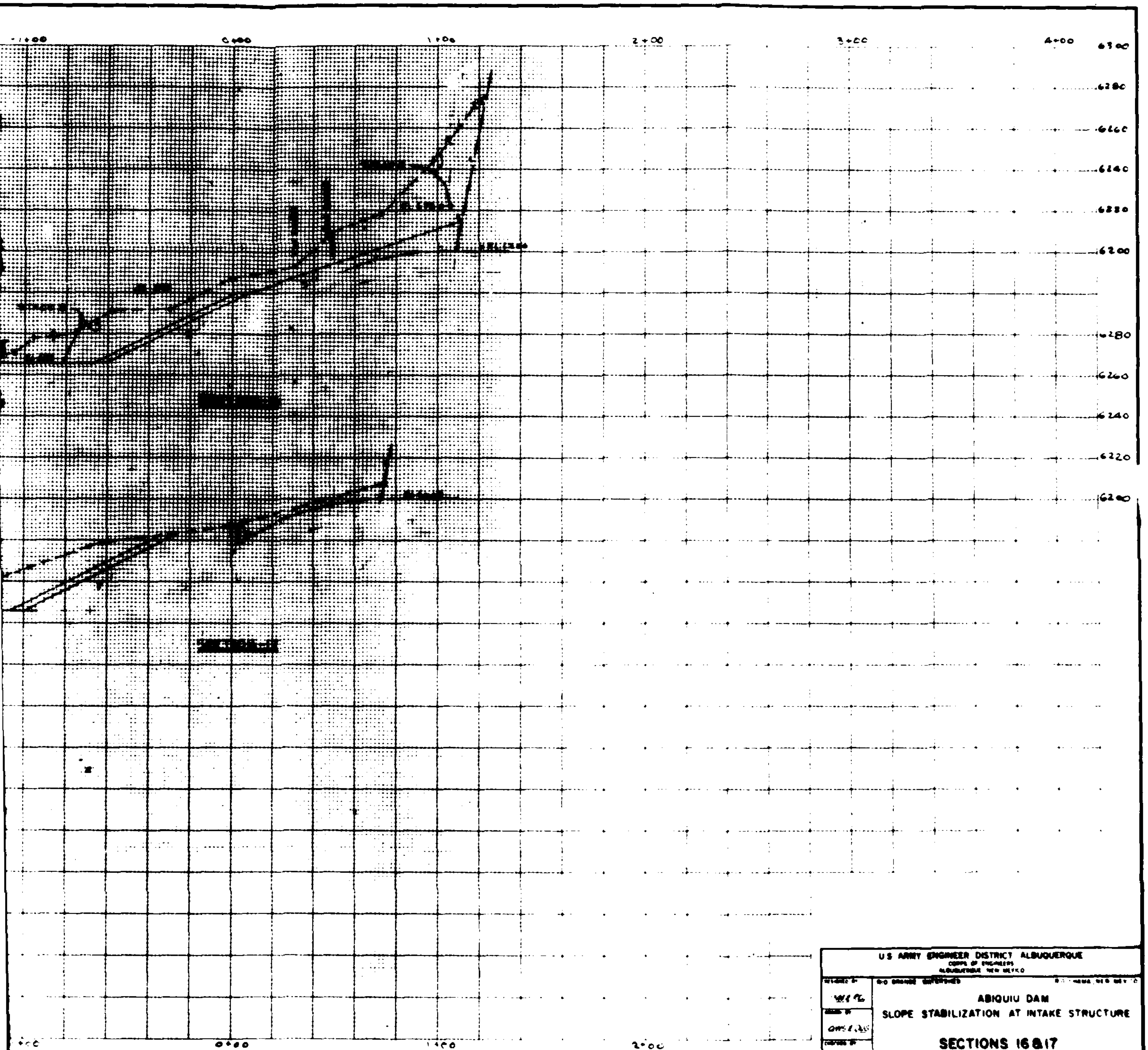
ABIQUIU DAM
SLOPE STABILIZATION AT INTAKE STRUCTURE

SECTIONS 13,14 & 15

DACW 47-78-B-0016
FILE NUMBER RG-AB-AM-7
PLATE 7



6200
6180
6160
6140
6120
6100
6080
6160
6140
6120
6100
6080
-3+00
-2+00
-1+00
0+00
1+00



US ARMY ENGINEER DISTRICT ALBUQUERQUE
CORPS OF ENGINEERS
ALBUQUERQUE, NEW MEXICO

RIO GRANDE WATERSHED

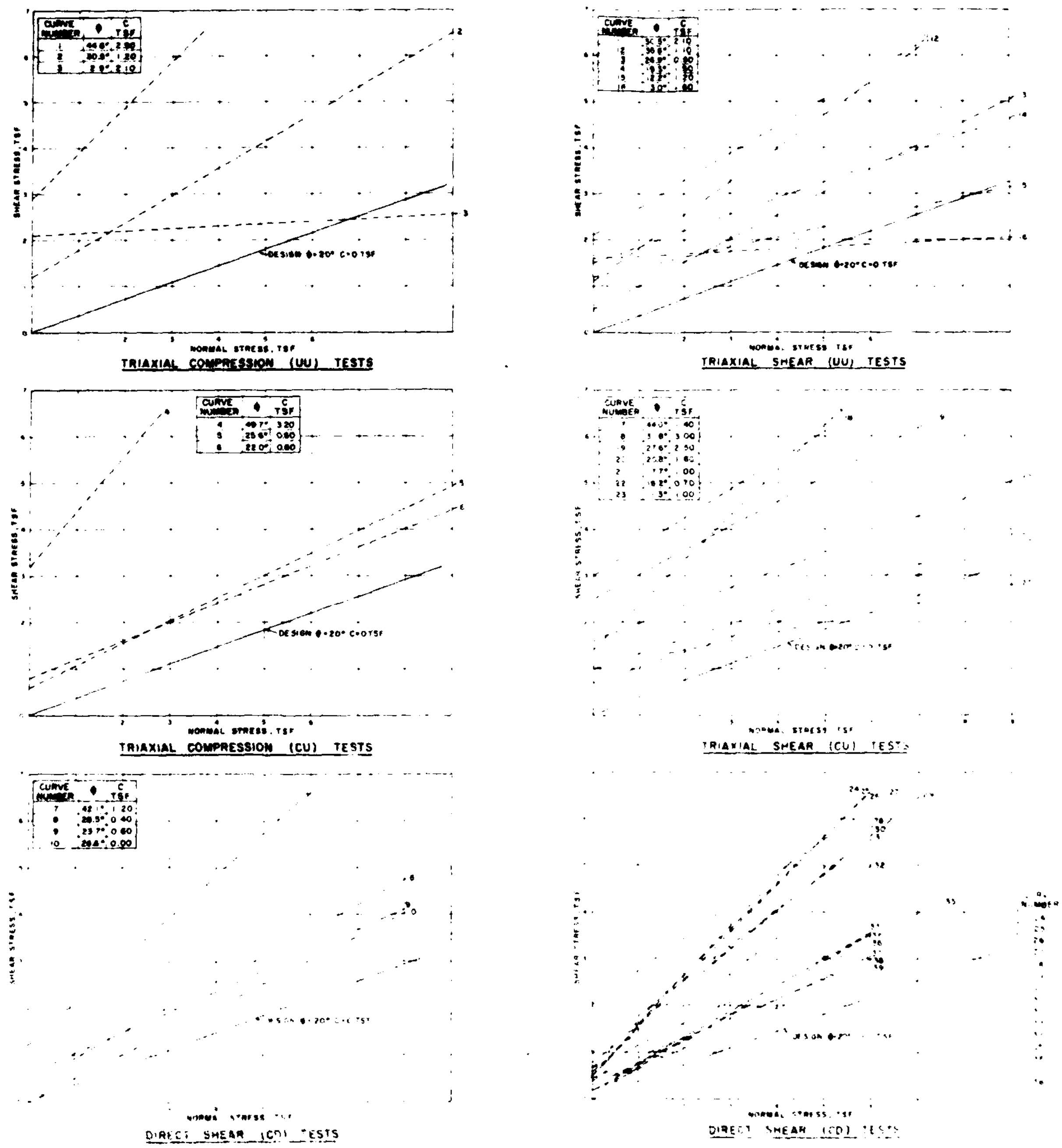
ABIQUIU DAM
SLOPE STABILIZATION AT INTAKE STRUCTURE

SECTIONS 16 & 17

DACW 47 78 B 0016

FILE NUMBER RG-AB-AM-8

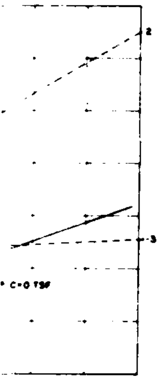
PLATE 8



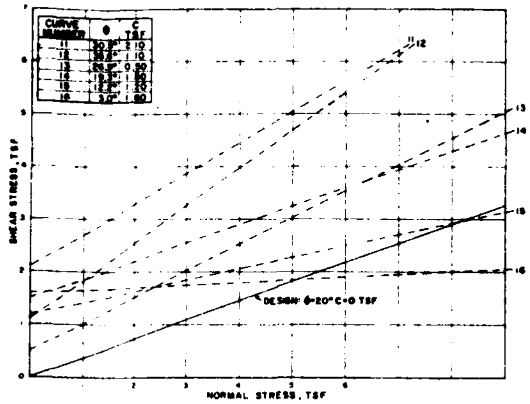
ABUTMENT PRIMARY FORMATION MATERIAL

STREAMBED PRIMARY FORMATION MATERIAL

U S ARMY

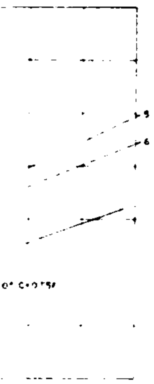


TESTS

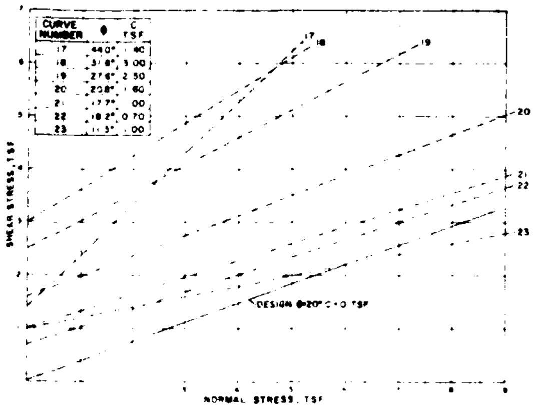


CURVE NUMBER	Φ	C TSF
11	30.[illegible]°	2.10
12	[illegible]	1.10
13	[illegible]	0.50
14	[illegible]	[illegible]
15	[illegible]	[illegible]
16	3.0°	1.80

TRIAXIAL SHEAR (UU) TESTS

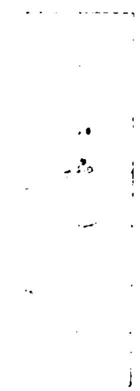


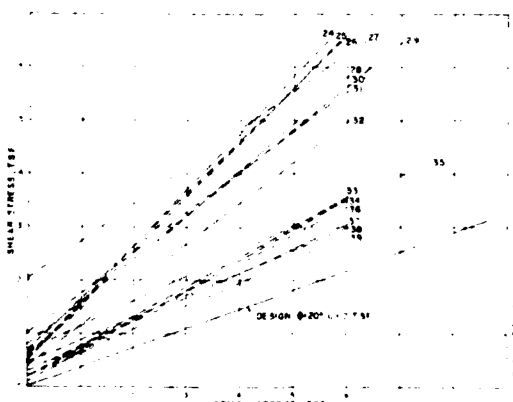
TESTS



CURVE NUMBER	Φ	C TSF
17	44.0°	[illegible]
18	31.8°	3.00
19	27.6°	2.50
20	20.8°	[illegible]
21	[illegible]	[illegible]
22	18.2°	0.70
23	[illegible]	[illegible]

TRIAXIAL SHEAR (CU) TESTS





CURVE NUMBER	Φ	C TSF
24	46.6°	0.50
25	45.8°	0.90
26	44.7°	[illegible]
27	[illegible]	2.04
28	[illegible]	[illegible]
9	19.2°	[illegible]
10	39.0°	0.80
[illegible]	[illegible]	[illegible]
[illegible]	37.5°	0.40
[illegible]	[illegible]	[illegible]
34	29.8°	[illegible]
[illegible]	[illegible]	[illegible]
36	[illegible]	[illegible]
[illegible]	24.7°	0.30
38	[illegible]	[illegible]
[illegible]	[illegible]	0.20

DIRECT SHEAR (CD) TESTS

MATERIAL

STREAMBED PRIMARY FORMATION MATERIAL

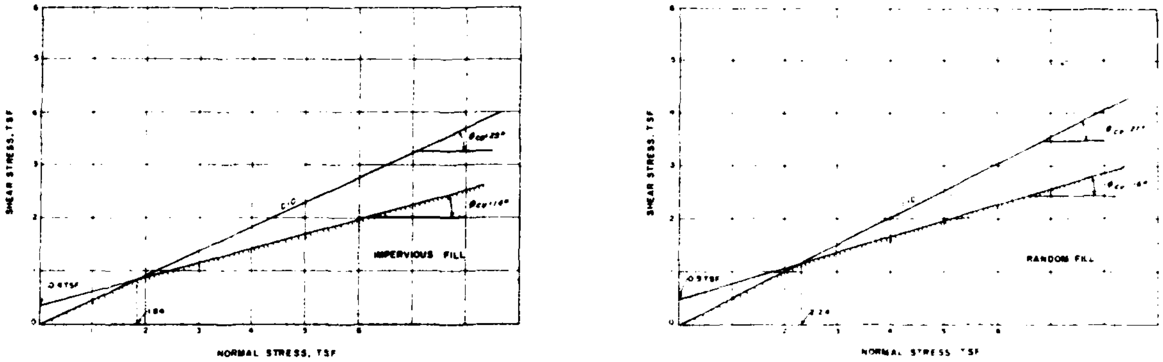
RIO GRANDE WATERSHED RIO CHAMA, NEW MEXICO
ABIQUIU DAM AND RESERVOIR

RESULTS OF SHEAR TESTS
EMBANKMENT FOUNDATION MATERIAL

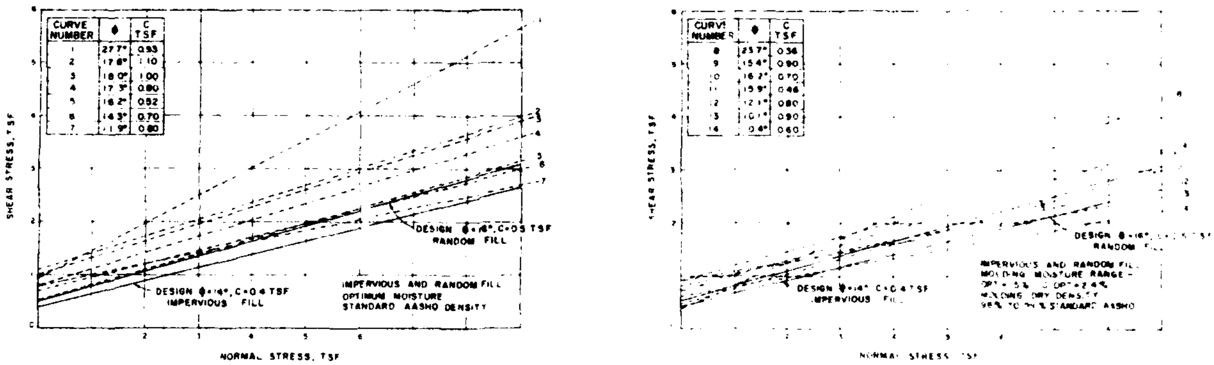
ALBUQUERQUE DISTRICT, ALBUQUERQUE, N.M.

TO ACCOMPANY DESIGN MEMORANDUM ON EMBANKMENT AND SPILLWAY DATED MAY 1958 | FILE NO RG-CH-G-24/8

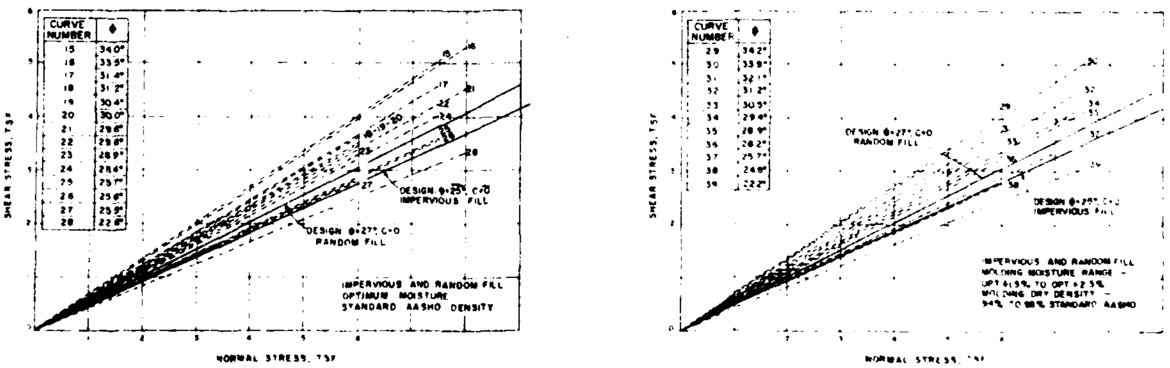
EMBANKMENT CRITERIA AND PERFORMANCE REPORT PLATE 28



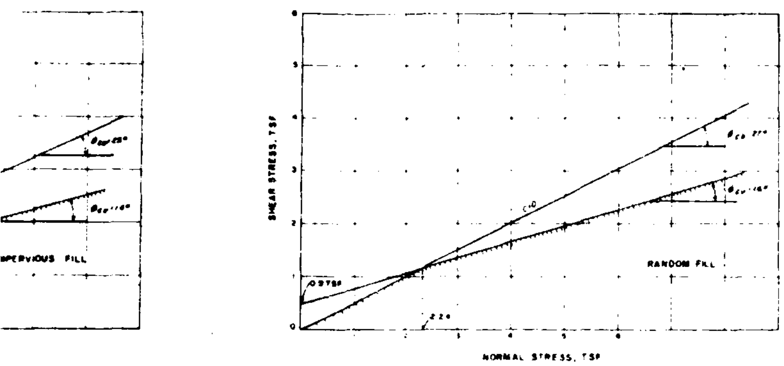
COMBINED CD-CU SHEAR STRENGTH ENVELOPES



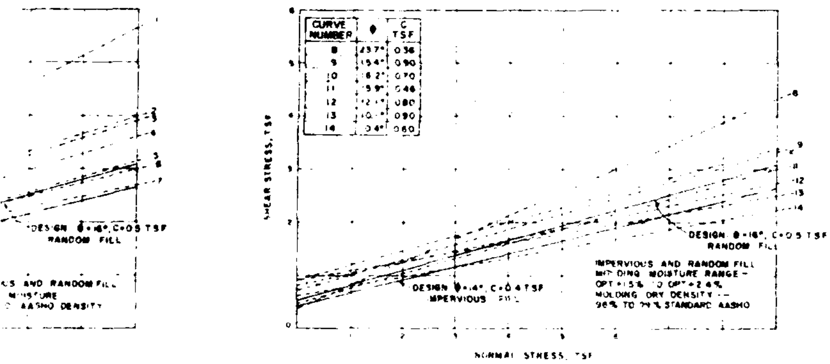
TRIAXIAL COMPRESSION (CU) TESTS



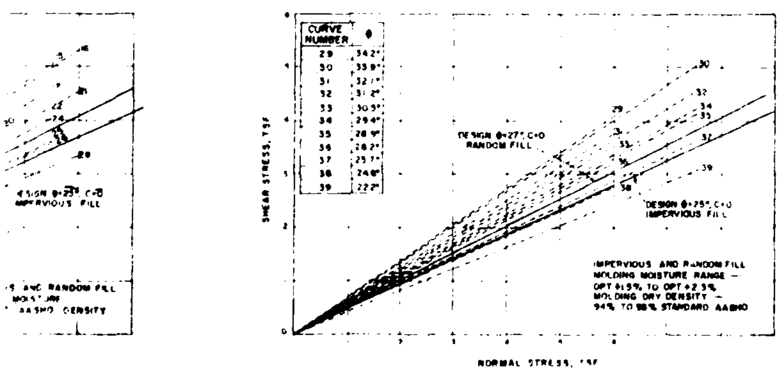
DIRECT SHEAR (CD) TESTS



COMBINED CD-CU SHEAR STRENGTH ENVELOPES



TRIAXIAL COMPRESSION (CU) TESTS

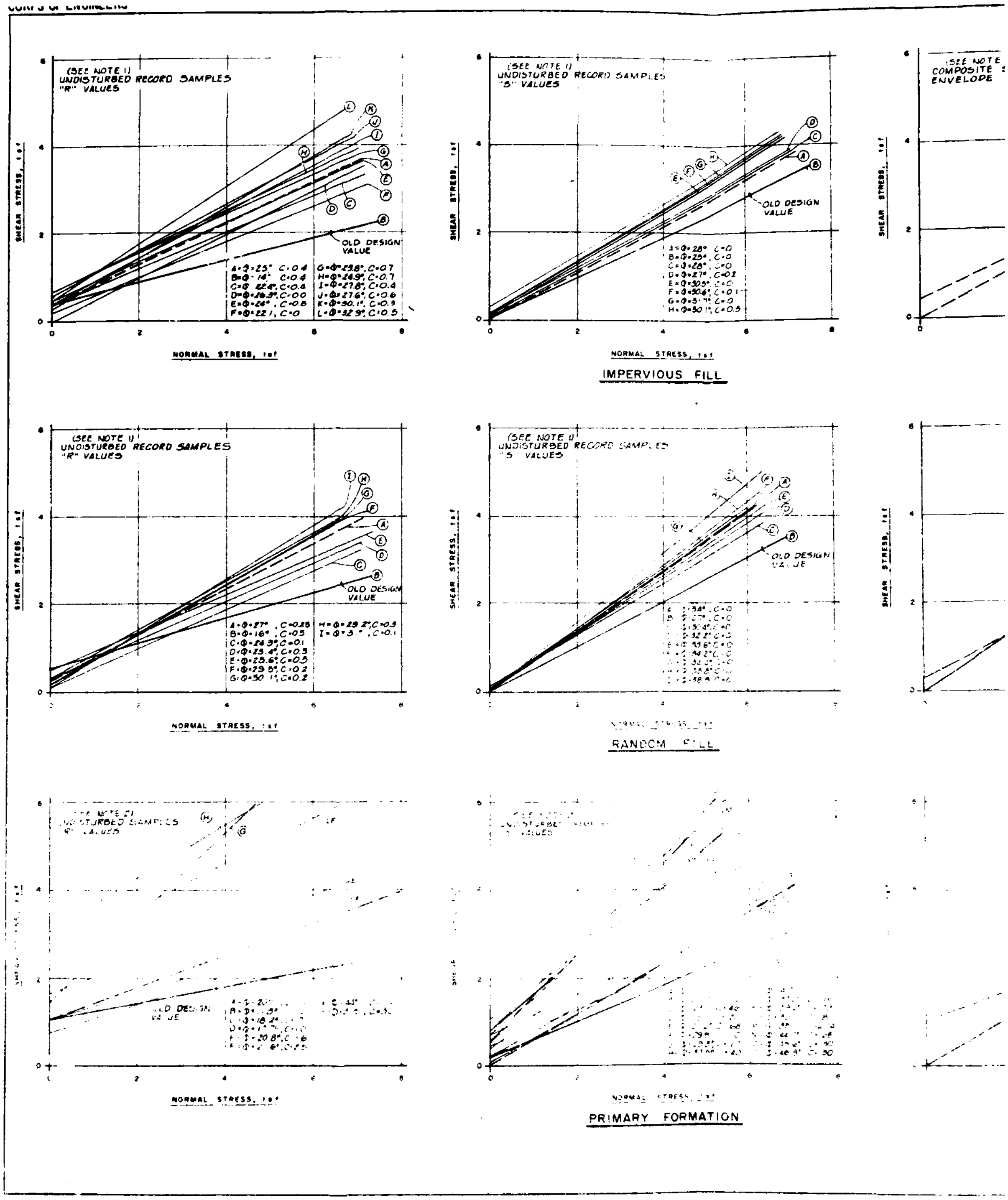


DIRECT SHEAR (CD) TESTS

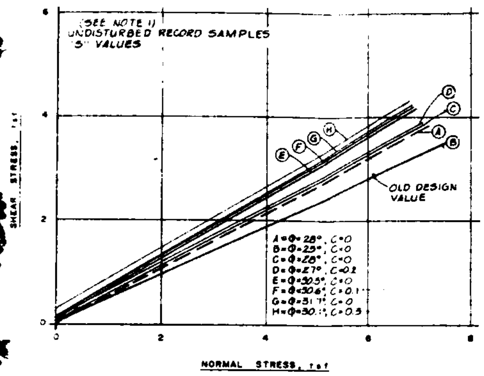
SAMPLE DATA

TEST NO.	SAMPLE NO.	BORROW AREA	WEIGHT RANGE: OPTIMUM MOISTURE	WEIGHT RANGE: MAXIMUM DENSITY	MOLDED SPECIMENS: MOISTURE AVG.	MOLDED SPECIMENS: DENSITY AVG.	CLASSIFICATION
1	[illegible]	[illegible]	[illegible]	118	[illegible]	[illegible]	Sandy Clay
2	Composite A	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Sandy Clay
3	Composite B	[illegible]	[illegible]	116	[illegible]	[illegible]	Clayey Sand
4	Composite C	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Sandy Clay
5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Sandy Clay
6	Composite [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	109	Sandy Clay
7	Composite [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Sandy Clay
8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Sandy Clay
9	Composite [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Clayey Sand
10	Composite [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Sandy Clay
11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Sandy Clay
12	Composite [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Sandy Clay
13	Composite [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Sandy Clay
14	Composite [illegible]	[illegible]	[illegible]	110	[illegible]	[illegible]	Sandy Clay
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

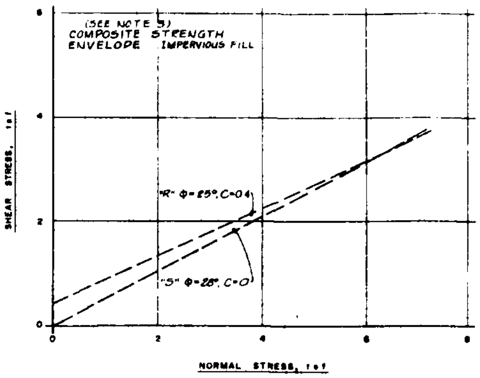
RIO GRANDE WATERSHED	RIO CHAMA, NEW MEXICO
ABIQUIU DAM AND RESERVOIR	
SHEAR SUMMARY CURVES	
IMPERVIOUS AND RANDOM BORROW MATERIAL	
ALBUQUERQUE DISTRICT, ALBUQUERQUE, N.M.	
TO ACCOMPANY DESIGN MEMORANDUM ON EMBANKMENT AND SPILLWAY DATED MAY 1958	FILE NO RG-CH-G-24/9

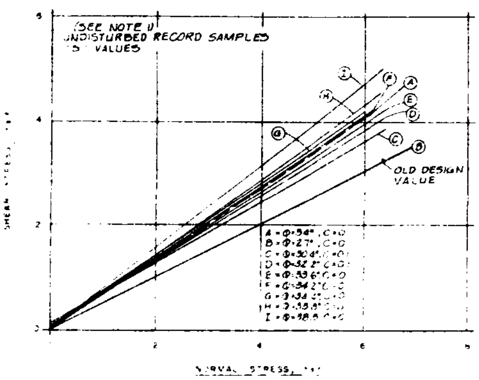


(SEE NOTE 1)
UNDISTURBED RECORD SAMPLES
"R" VALUES
SHEAR STRESS, tsf
NORMAL STRESS, tsf
OLD DESIGN VALUE
A=Φ=25°, C=0.4
B=Φ=14°, C=0.4
C=Φ=22.4°, C=0.4
D=Φ=26.5°, C=0.0
E=Φ=24°, C=0.8
F=Φ=22.1, C=0
G=Φ=25.8°, C=0.7
H=Φ=24.9°, C=0.7
I=Φ=27.8°, C=0.4
J=Φ=27.6°, C=0.6
K=Φ=30.1°, C=0.3
L=Φ=32.9°, C=0.5
(SEE NOTE 1)
UNDISTURBED RECORD SAMPLES
"S" VALUES
IMPERVIOUS FILL
(SEE NOTE
COMPOSITE
ENVELOPE
A=Φ=27°, C=0.25
B=Φ=16°, C=0.5
C=Φ=26.3°, C=0.1
D=Φ=25.4°, C=0.5
E=Φ=25.6°, C=0.5
F=Φ=29.5°, C=0.2
G=Φ=30.1°, C=0.2
H=Φ=29.2°, C=0.5
RANDOM FILL
PRIMARY FORMATION

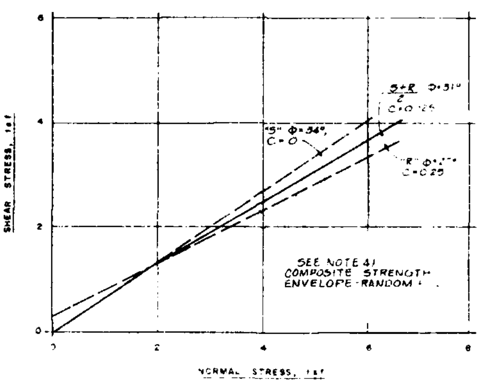


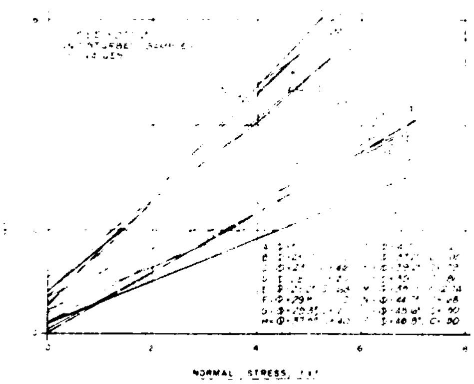
IMPERVIOUS FILL



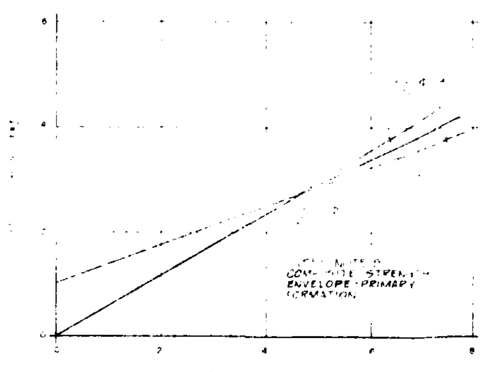


RANDOM FILL





PRIMARY FORMATION



NOTES
1. UNDISTURBED RECORD SAMPLES TAKEN DURING CONSTRUCTION
2. UNDISTURBED SAMPLES TAKEN DURING DESIGN, SEE DM #7, R 8
3. "S" STRENGTH VALUES WERE USED FOR ALL STABILITY ANALYSES
4. "S" STRENGTH VALUES WERE USED FOR MATERIAL ABOVE 21, BELOW 21' R+S/2 VALUES WERE USED FOR STEADY SEEPAGE AND EARTHQUAKE WITH SEEPAGE. "R" VALUES WERE USED BELOW 21' FOR SUDDEN DRAWDOWN ANALYSIS.
5. "S" STRENGTH VALUES WERE USED FOR MATERIAL ABOVE 65', BELOW 65' R+S/2 VALUES WERE USED FOR CONDITIONS.

SHEAR STRENGTHS

MATERIAL	ANGLE OF FRICTION-Φ SUDDEN DRAW-DOWN	STEADY SEE-PAGE	EARTH-QUAKE	SHEAR TEST CONDITION SUDDEN DRAW-DOWN	STEADY SEE-PAGE	EARTH-QUAKE
PERVIOUS	35°	35°	35°	S	S	S
RANDOM	27°	31°	31°	R	R+S/2	R+S/2
	34°	34°	34°	S	S	S
IMPERVIOUS	28°	28°	28°	S	S	S
PRIMARY FORMATION	30°	25°	25°	S	R+S/2	R+S/2
STREAM BED ALLUVIUM	35°	35°	35°	S	S	S
WASTE	20°	—	—	S	—	—

MATERIAL	C-COHESION, tsf SUDDEN DRAW-DOWN	STEADY SEE-PAGE	EARTH-QUAKE
PERVIOUS	0	0	0
RANDOM	.25	.25	.25
	0	0	
IMPERVIOUS	0	0	0
PRIMARY FORMATION	0	[illegible]	.5
STREAM BED ALLUVIUM	0	0	[illegible]
WASTE	0		—

RIO GRANDE WATERSHED — RIO CHAMA, NEW MEX.

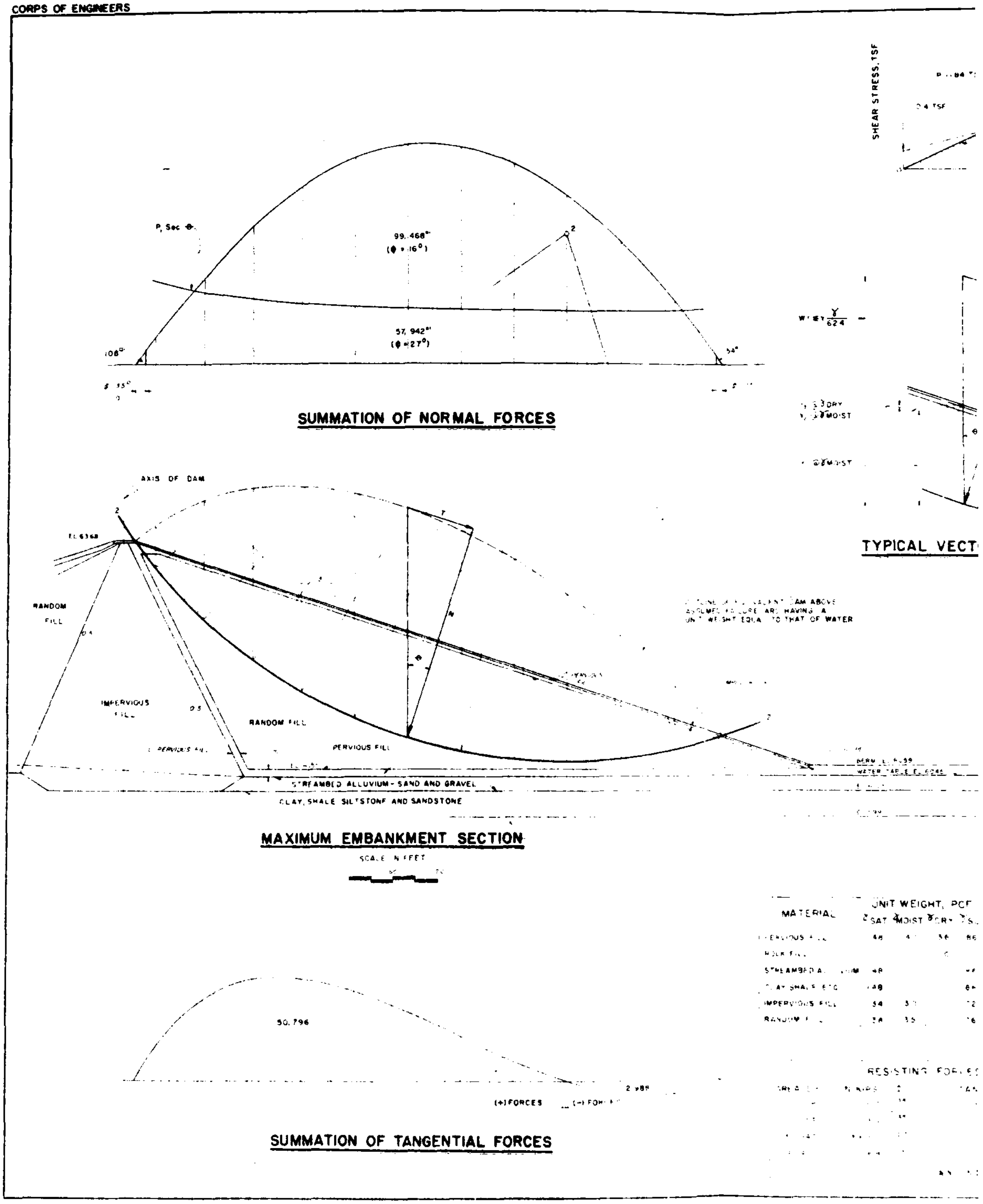
ABIQUIU DAM AND RESERVOIR

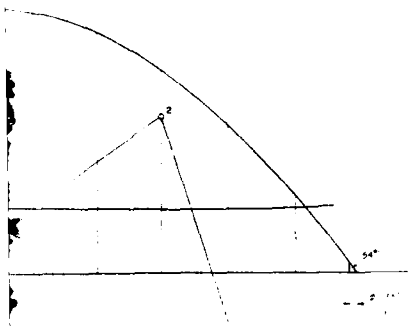
SHEAR STRENGTHS FOR STABILITY ANALYSIS

US ARMY ENGINEER DISTRICT, ALBUQUERQUE, N.M.

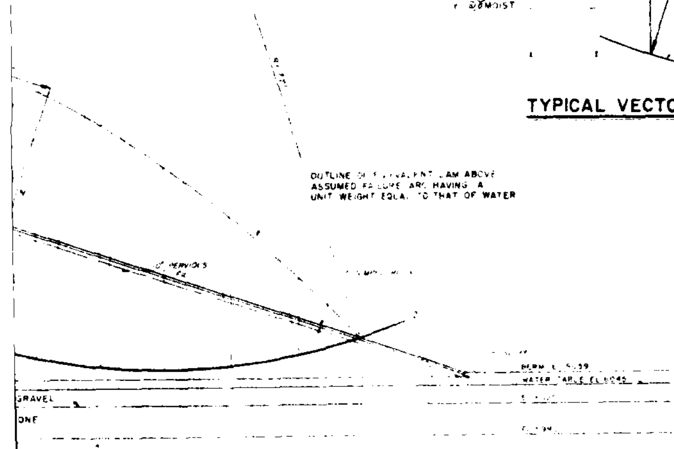
FILE NO

CORPS OF ENGINEERS

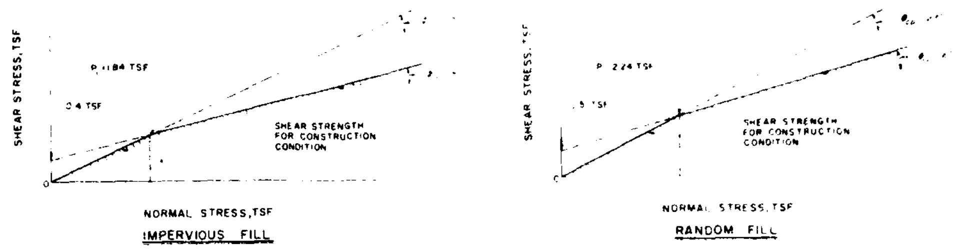




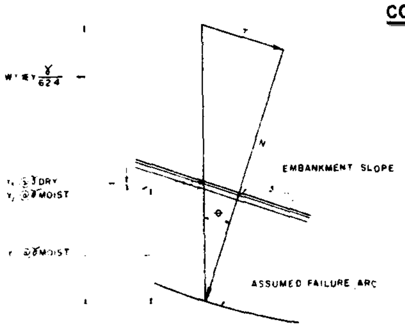
RMAL FORCES



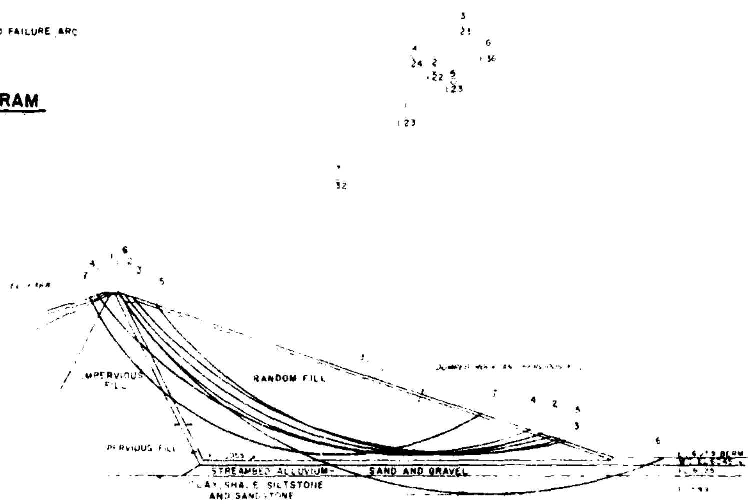
SECTION



COMBINED CD-CU SHEAR STRENGTH ENVELOPES



TYPICAL VECTOR DIAGRAM



LOCATION OF TRIAL FAILURE ARCS
MAXIMUM EMBANKMENT SECTION

SCALE IN FEET

MATERIAL	UNIT WEIGHT, PCF				SHEAR STRENGTH CD (DS)	
	γ_{SAT}	γ_{MOIST}	γ_{DRY}	γ_{SUB}	ϕ	C, PSF
PERVIOUS FILL	148	140	136	86	35°	0
ROCK FILL			120		45°	0
STREAMBED ALLUVIUM	148			86	35°	0
CLAY SHALE, ETC	148			86	20°	0
IMPERVIOUS FILL	134	130		72	SEE STRENGTH ENVELOPES	
RANDOM FILL	138	135		76		

RESISTING FORCES

AREA, S.F.	N, KIPS	ϕ	TAN ϕ	N TAN ϕ, KIPS
[illegible]	[illegible]	35°	[illegible]	[illegible]
[illegible]	[illegible]	35°	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	644
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
			Σ N TAN ϕ	[illegible]

DRIVING FORCES

AREA, S.F.	T, KIPS
50,796	[illegible]
2,998	[illegible]
	Σ T [illegible]

2,988

(+) FORCES (−) FORCES

TIAL FORCES

RIO GRANDE WATERSHED RIO CHAMA, NEW MEXICO
ABIQUIU DAM AND RESERVOIR

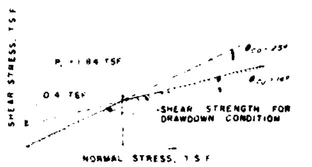
STABILITY ANALYSIS- DOWNSTREAM SLOPE
CONSTRUCTION CONDITION

SCALE AS SHOWN

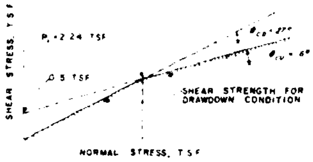
ALBUQUERQUE DISTRICT , ALBUQUERQUE , N M

TO ACCOMPANY DESIGN MEMORANDUM ON EMBANKMENT AND SPILLWAY
DATED MAY 1958
FILE NO RG-CH-G-24/13

CORPS OF ENGINEERS

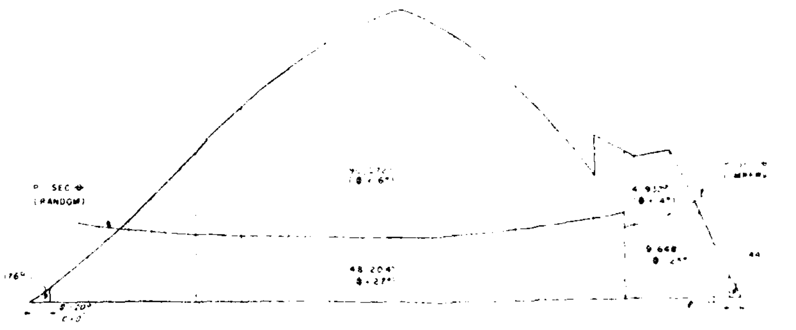


IMPERVIOUS FILL

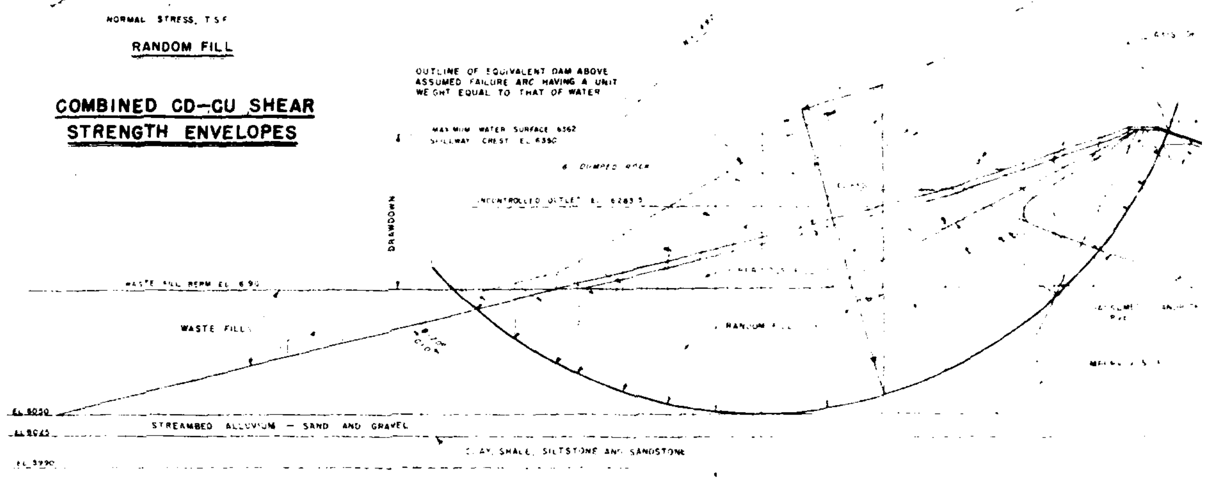


RANDOM FILL

COMBINED CD—CU SHEAR STRENGTH ENVELOPES

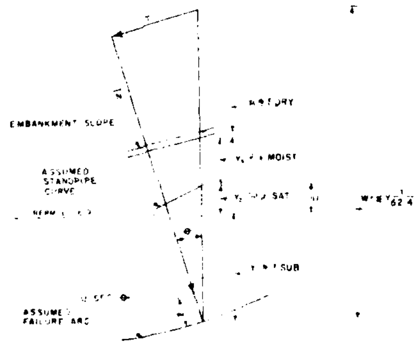


SUMMATION OF NORMAL FORCES

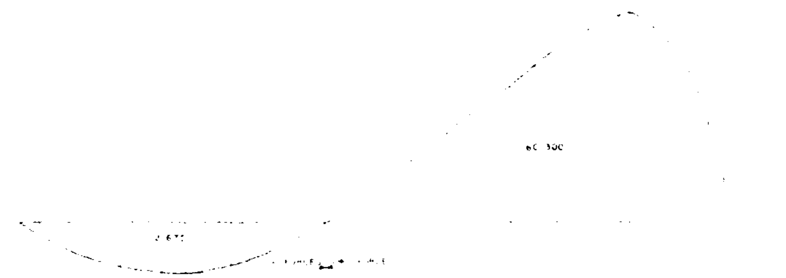


MAXIMUM EMBANKMENT SECTION

SCALE IN FEET

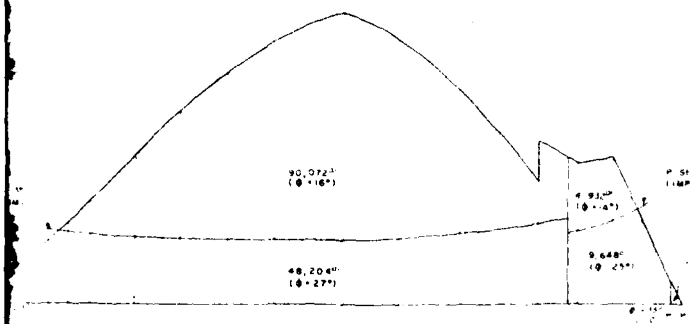


TYPICAL VECTOR DIAGRAM

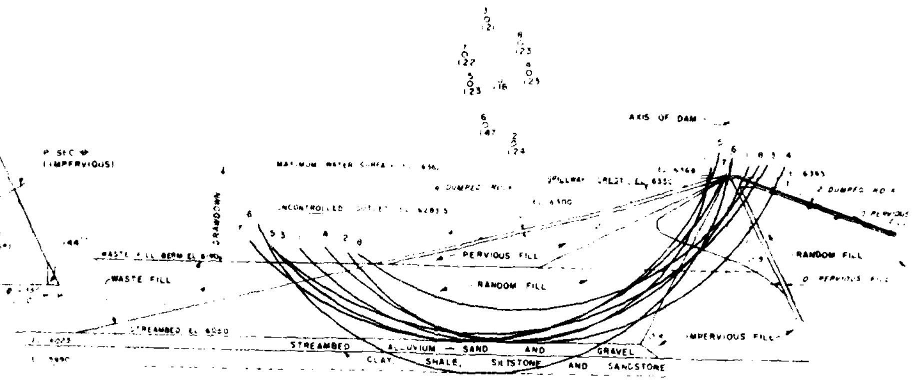


SUMMATION OF TANGENTIAL FORCES

U S ARMY



SUMMATION OF NORMAL FORCES

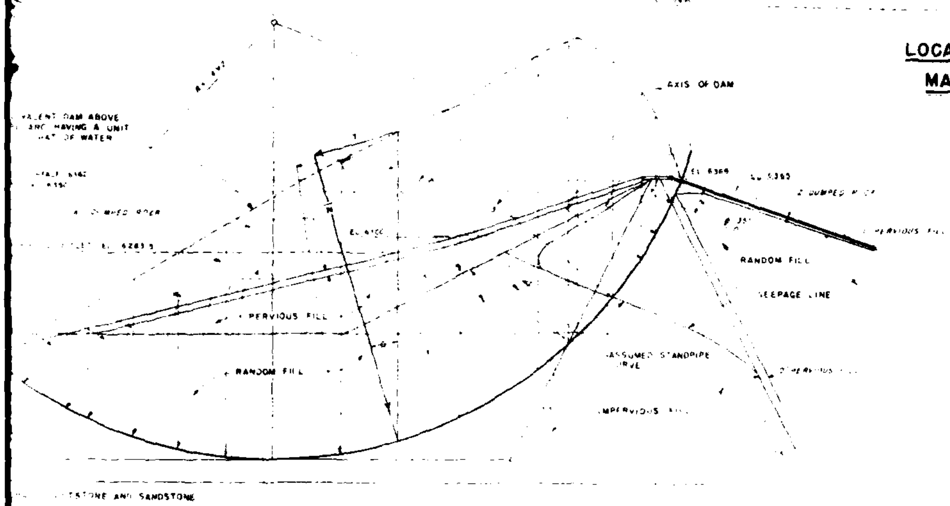


LOCATION OF TRIAL FAILURE ARCS

MAXIMUM EMBANKMENT SECTION

SCALE IN FEET

0 100 200



MAXIMUM EMBANKMENT SECTION

SCALE IN FEET

0 60 120

MATERIAL	UNIT WEIGHT, PCF				SHEAR STRENGTH CD (DS)	
	γ SAT	γ MOIST	γ DRY	γ SUB	φ	C, PSF
PERVIOUS FILL	148	140		86	35°	0
DUMPED ROCK			100		35°	0
STREAMBED ALLUVIUM	148			86	35°	0
CLAY, SHALE, ETC	148			86	20°	0
IMPERVIOUS FILL	134	130		72	SEE STRENGTH ENVELOPES	
RANDOM FILL	138	135		76		
WASTE FILL	115			53	20°	[illegible]

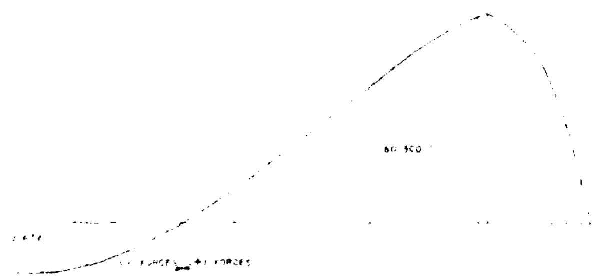
RESISTING FORCES

AREA, S.F.	N, KIPS	φ	TAN φ	N TAN φ, KIPS
176	[illegible]	20°	0.3[illegible]4	[illegible]
[illegible]072	5,6[illegible]	16°	0.28[illegible]	[illegible]
48,204	[illegible]	27°	[illegible]50	[illegible]
4,932	[illegible]	14°	0.249	[illegible]
9,648	602.0	25°	0.46[illegible]	280.[illegible]
44	9.[illegible]	35°	0.70[illegible]	6.[illegible]
			ΣN TAN φ =	[illegible],5[illegible]4.5

DRIVING FORCES

AREA, S.F.	T, KIPS
60,[illegible]	[illegible]
2,672	[illegible]
	ΣT = 2,97[illegible]

SAFETY FACTOR = $\frac{\Sigma N \tan\phi}{\Sigma T}$ = [illegible]



SUMMATION OF TANGENTIAL FORCES

NOTE

[illegible]

RIO GRANDE WATERSHED RIO CHAMA, NEW MEXICO

ABIQUIU DAM AND RESERVOIR

STABILITY ANALYSIS — UPSTREAM SLOPE

SUDDEN DRAWDOWN FROM MAXIMUM

WATER SURFACE EL 6362 TO EL 6190

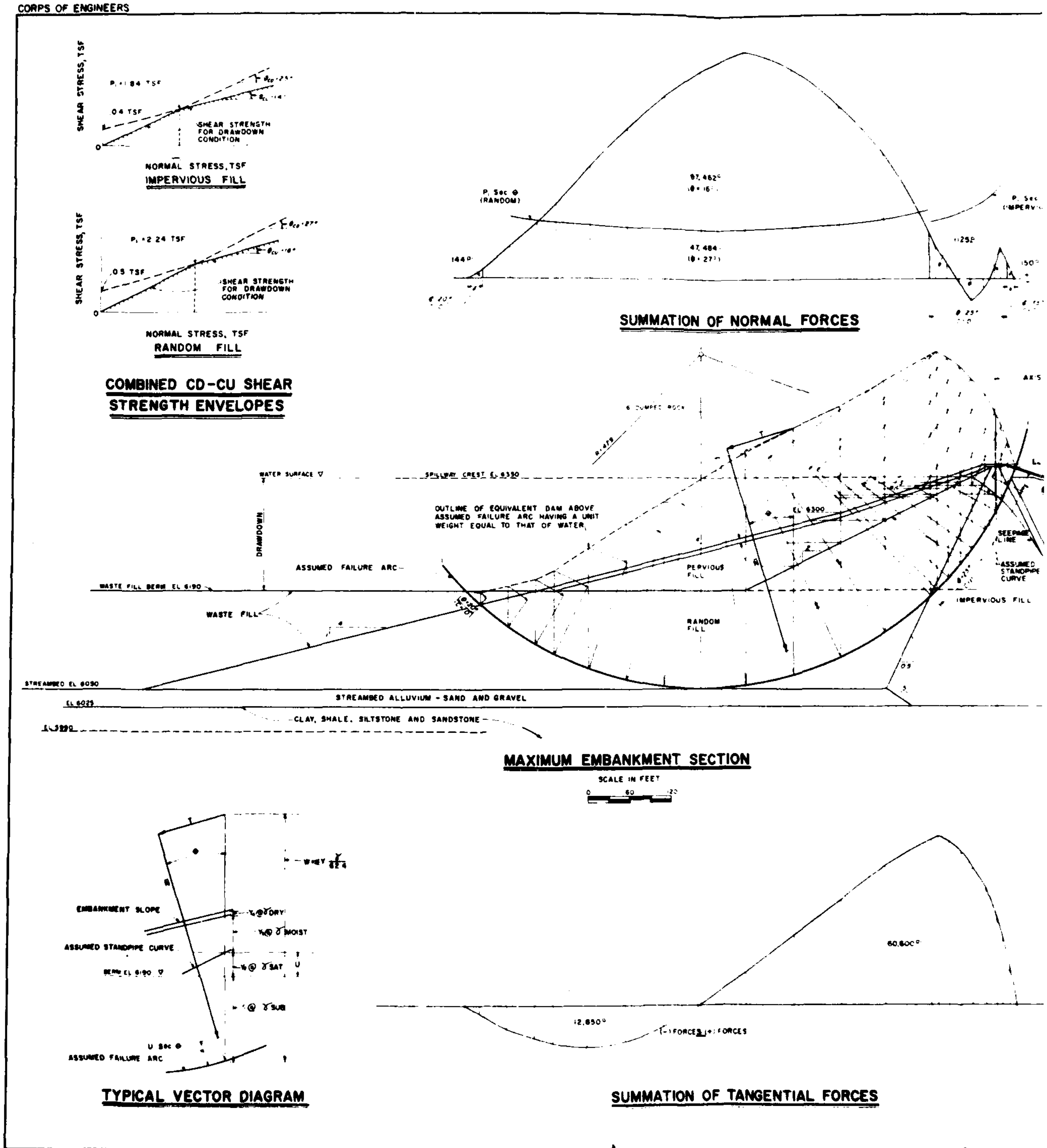
SCALE AS SHOWN

ALBUQUERQUE DISTRICT, ALBUQUERQUE, N M

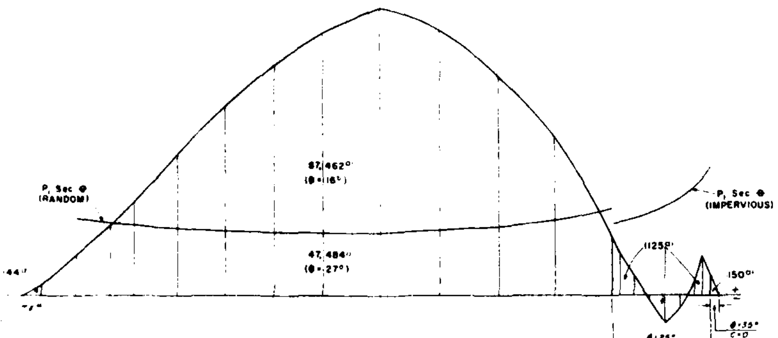
TO ACCOMPANY DESIGN MEMORANDUM ON EMBANKMENT AND SPILLWAY DATED MAY 1958

FILE NO RG-CH-G-24/10

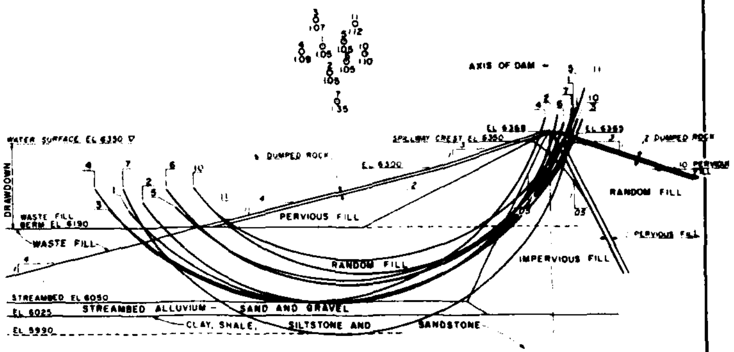
CORPS OF ENGINEERS



U S ARMY

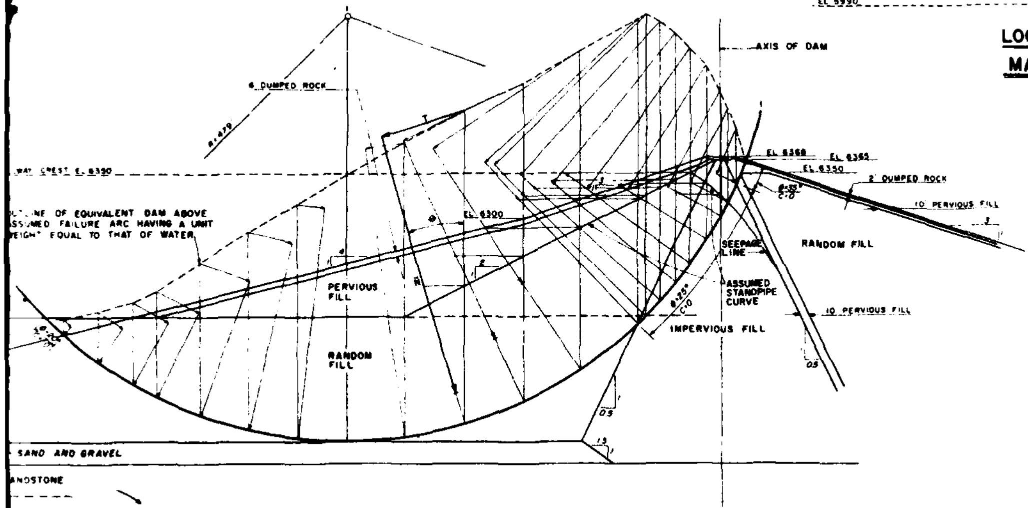


SUMMATION OF NORMAL FORCES



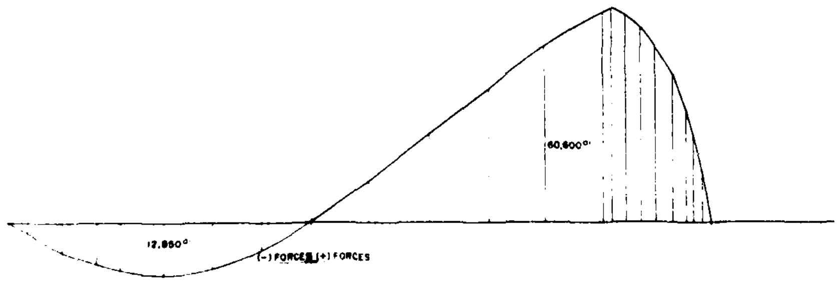
LOCATION OF TRIAL FAILURE ARCS
MAXIMUM EMBANKMENT SECTION

SCALE IN FEET
0 100 200



MAXIMUM EMBANKMENT SECTION

SCALE IN FEET
0 60 120



SUMMATION OF TANGENTIAL FORCES

MATERIAL	UNIT WEIGHT, PCF				SHEAR STRENGTH CD (DS)	
	γ SAT.	γ MOIST	γ DRY	γ SUB	φ	C, PSF
PERVIOUS FILL	148	140		86	35°	0
DUMPED ROCK			100		35°	0
STREAMBED ALLUVIUM	148			86	35°	0
CLAY, SHALE, ETC	148			86	20°	0
IMPERVIOUS FILL	134	130		72	SEE STRENGTH ENVELOPES	
RANDOM FILL	138	135		76		
WASTE FILL	115			53	20°	0

RESISTING FORCES

AREA, S F	N, KIPS	φ	TAN φ	N TAN φ, KIPS
144	9 0	20°	364	3 3
87,462	5,457.6	16°	287	1,566 3
47,484	2,963 0	27°	510	1,511 1
1,125	70 2	25°	466	32 7
150	9 4	35°	700	6 6
			ΣN TAN φ =	3,120 0'

DRIVING FORCES

AREA, S.F.	T, KIPS
60,600	3,781 4
-12,850	-801 8
ΣT =	2,979 6'

SAFETY FACTOR $= \frac{\Sigma N \tan \phi}{\Sigma T} = \frac{3{,}120\ 0'}{2{,}979\ 6'} = 1\ 05$

RIO GRANDE WATERSHED RIO CHAMA, NEW MEXICO
ABIQUIU DAM AND RESERVOIR

STABILITY ANALYSIS–UPSTREAM SLOPE SUDDEN DRAWDOWN FROM SPILLWAY CREST EL 6350 TO EL 6190

SCALE AS SHOWN

ALBUQUERQUE DISTRICT, ALBUQUERQUE, N. M.

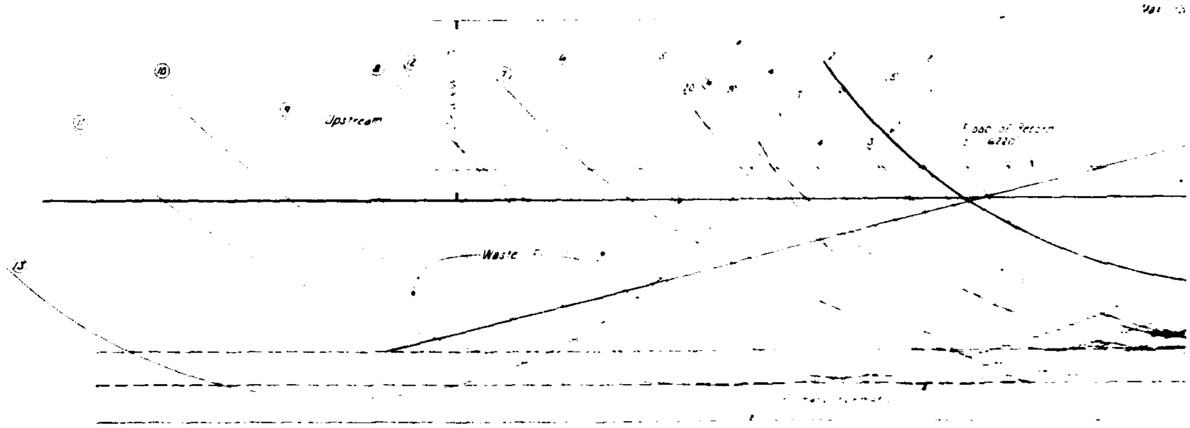
TO ACCOMPANY DESIGN MEMORANDUM ON EMBANKMENT AND SPILLWAY DATED: MAY 1958

FILE NO RG-CH-G-24/11

Arc	X	Y	R		F.S.
1	-250	50	370		3.27
2	-350	50	383		2.82
3	-400	150	465		2.12
4	-400	250	566		2.14
5	-450	350	663		2.06
6	-500	350	700		2.55
7	-550	450	766		1.99
8	-650	450	766		2.51
9	-700	550	903		2.45
10	-800	550	900		2.66
11	-900	584	940		2.76
12	-700	250	600		3.08
13	-1282	100	465		1.95
14	-435	170	500		2.34
15	-405	55	374		2.51
16	-460	285	593		1.97
17	-375	185	310		2.43
18	-490	165	487		2.40
19	-460	85	469		2.75
20	-500	217	540		2.66
21	-400	241	504		1.92

STRENGTH VALUES

Material	Unit Weight PCF	ø	C	Strength
Pervious (moist)	[illegible]	35°	[illegible]	[illegible]
Random (sat)	[illegible]	27°	125	R
Random (moist)	35	34°	[illegible]	[illegible]
Impervious (sat)	24	18°	[illegible]	[illegible]
Impervious (moist)	30	28°	0	[illegible]
Streambed (sat) Alluvium	48	35°	0	[illegible]
Waste (sat)	115	20°	[illegible]	[illegible]
Primary Formation (sat)	48	30°	[illegible]	[illegible]



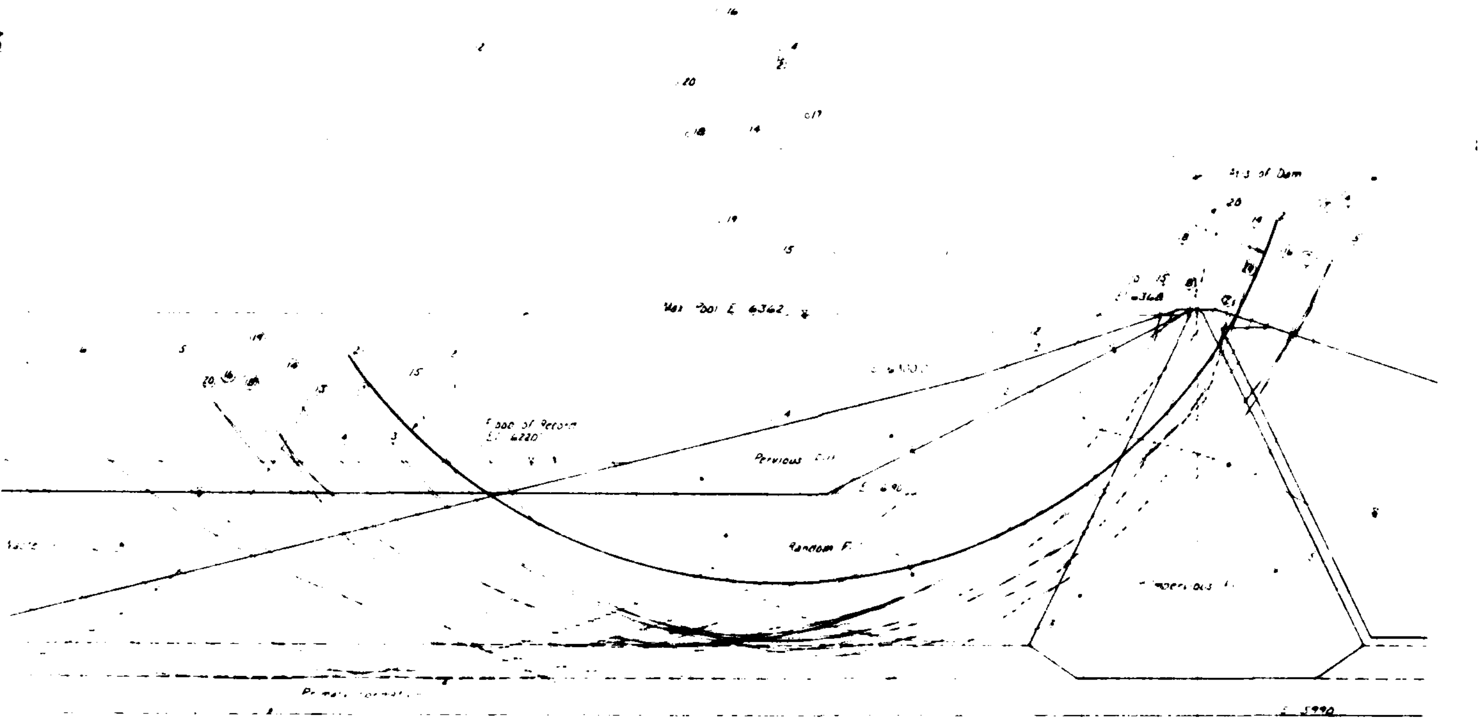
LOCATION OF TRIAL FAILURE ARCS

MAXIMUM EMBANKMENT SECTION

SCALE 1" = 50'-0

STRENGTH VALUES

Material	Unit Weight PCF	ø	C	Strength
Pervious (moist)	[illegible]43	35°	0	[illegible]
Random (sat)	[illegible]40	27°	0.25	[illegible]
Random (moist)	35	34°	0	[illegible]
Impervious (sat)	[illegible]24	28°	0	[illegible]
Impervious (moist)	30	28°	0	[illegible]
[illegible] (sat) Alluvium	[illegible]48	35°	0	[illegible]
Basalt (sat)	[illegible]115	20°	0	[illegible]
Primary Formation (sat)	[illegible]48	30°	0	[illegible]



Note: Computer Solutions by use of the Simplified Bishop Analysis, Programmed for the GE 225 Computer [illegible]

LOCATION OF TRIAL FAILURE ARCS

MAXIMUM EMBANKMENT SECTION

SCALE 1" = 50'-0"

REVISIONS

U. S. ARMY ENGINEER DISTRICT ALBUQUERQUE
CORPS OF ENGINEERS
ALBUQUERQUE, NEW MEXICO

RIO GRANDE WATERSHED — RIO CHAMA, NEW MEXICO

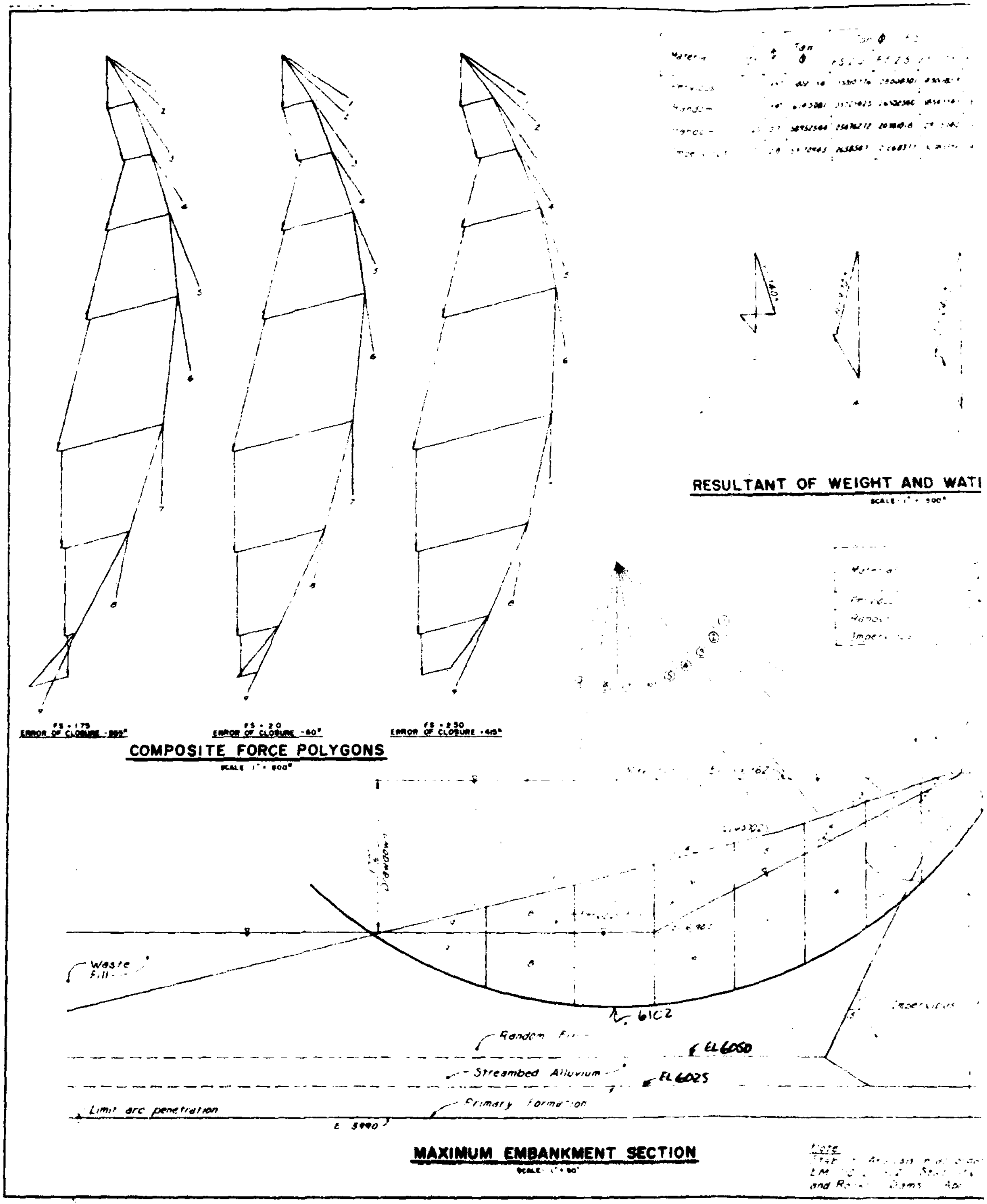
ABIQUIU DAM AND RESERVOIR

STABILITY ANALYSIS, UPSTREAM SLOPE, SUDDEN DRAWDOWN CONDITION

COMPUTER SOLUTION

FILE NUMBER

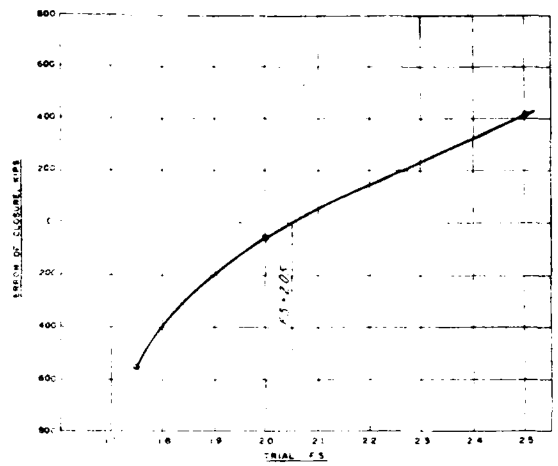
PLATE 24


COMPOSITE FORCE POLYGONS
RESULTANT OF WEIGHT AND WAT
Waste Fill
Random Fill
Streambed Alluvium
Primary Formation
Limit arc penetration
EL 6050
EL 6025
MAXIMUM EMBANKMENT SECTION

Material	[illegible]	Tan ϕ	Tan ϕ / F.S. F.S 2.0	F.S 2.5	F.S 1.75	Arc tan for F.S. F.S 2.0	F.S 2.5	F.S 1.75
Pervious	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Random	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Random	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Impervious	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

RESULTANT OF WEIGHT AND WATER FORCES ON SLICE

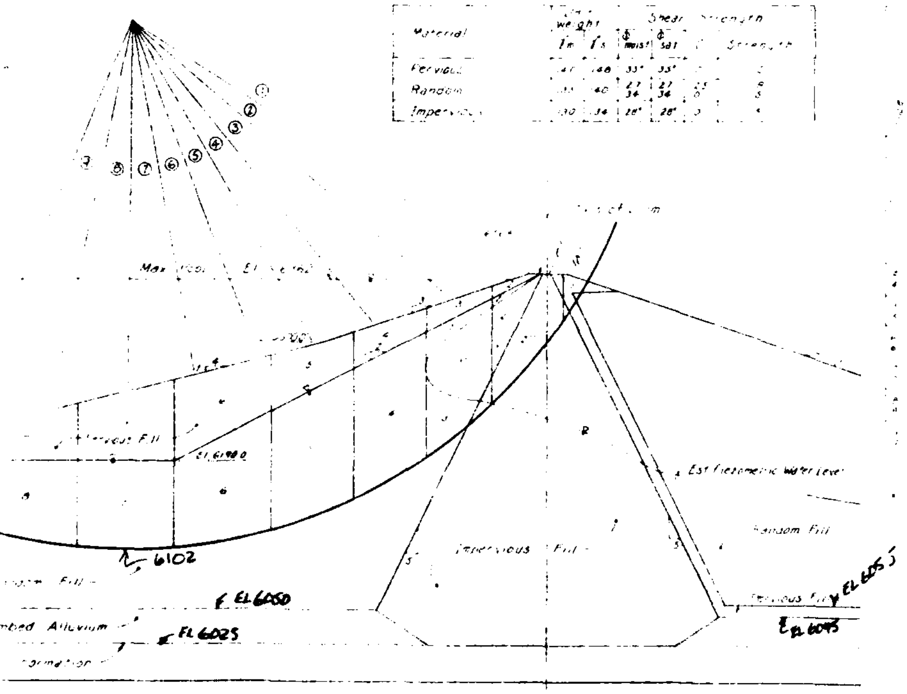
SCALE: 1" = 500#



TRIAL FACTOR OF SAFETY VS ERROR OF CLOSURE

Material	Unit weight γ_m	γ_s	Shear strength ϕ moist	ϕ sat	[illegible]	Strength
Pervious	[illegible]	146	33°	33°	[illegible]	[illegible]
Random	[illegible]	140	[illegible]	[illegible]	[illegible]	[illegible]
Impervious	130	134	28°	28°	[illegible]	[illegible]

Slice	Slice height		Average	Area of Slice	Weight		Water pressure					
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]



EMBANKMENT SECTION

SCALE: 1" = 80'

Note:
Analysis in accordance with EM 1110-2-1902 "Stability of Earth and Rock Dams," April 1970

RIO GRANDE WATERSHED RIO CHAMA, NEW MEXICO

ABIQUIU DAM AND RESERVOIR

STABILITY ANALYSIS - UPSTREAM SLOPE SUDDEN DRAWDOWN CONDITION

MANUAL SOLUTION

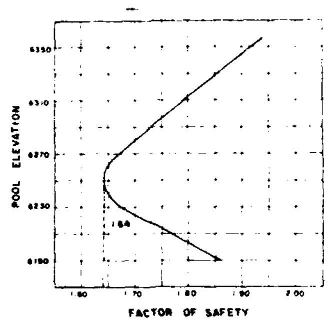
US ARMY ENGINEER DISTRICT, ALBUQUERQUE, N M

FILE NO

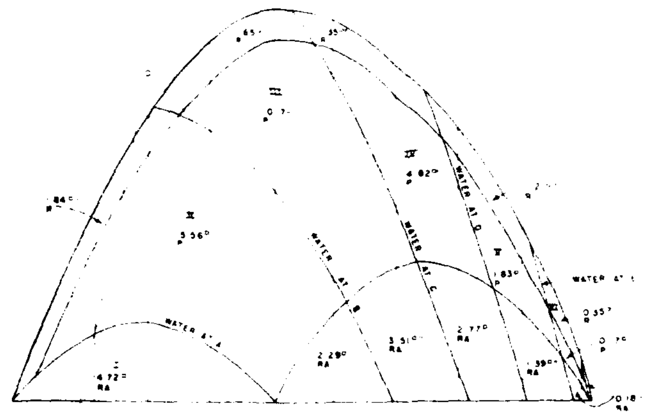
TO ACCOMPANY PERIODIC INSPECTION REPORT NO. 2

DATE OCT 1976

2



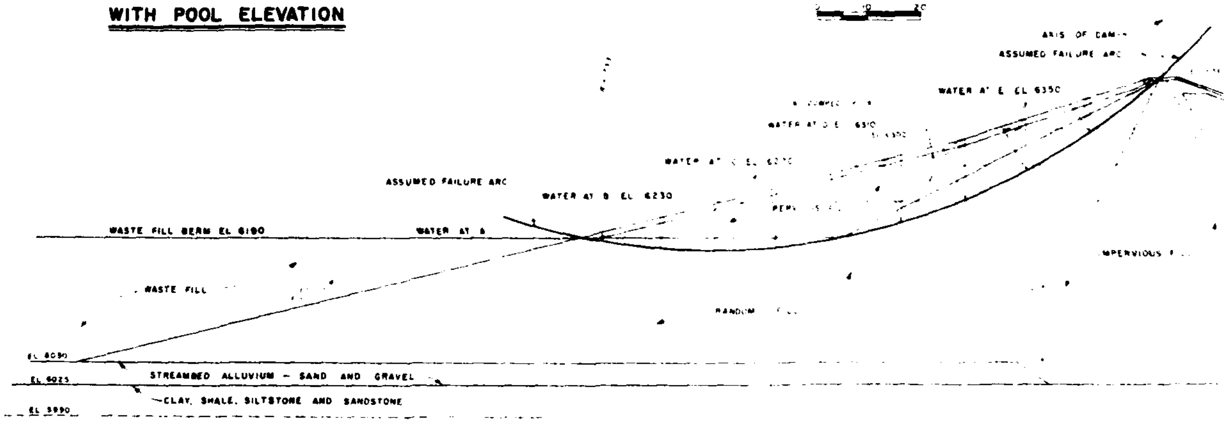
VARIATION OF SAFETY FACTOR WITH POOL ELEVATION



SUMMATION OF NORMAL FORCES

HORIZONTAL SCALE IN FEET

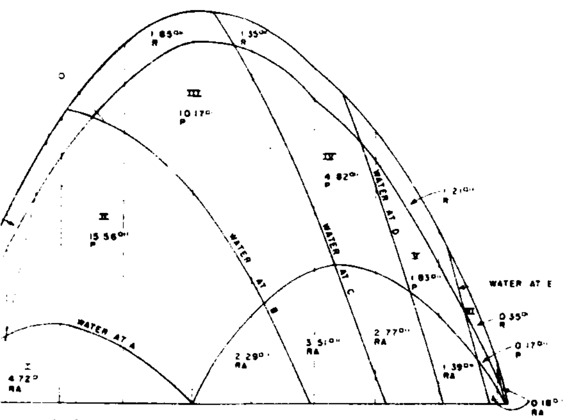
VERTICAL SCALE IN FEET



MAXIMUM EMBANKMENT SECTION

SCALE IN FEET

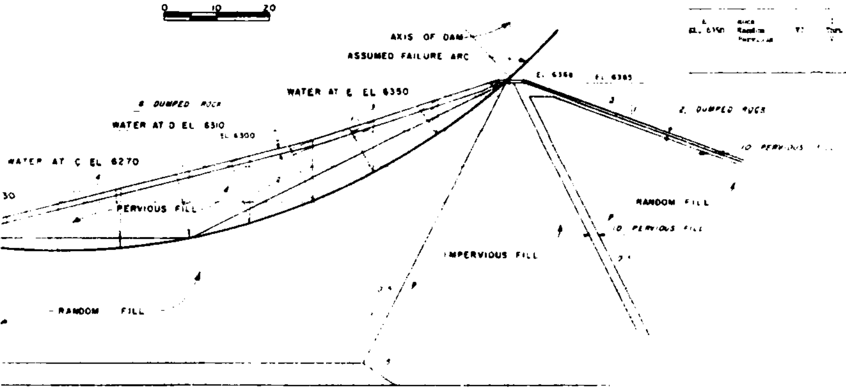
SUMMATION OF TANGENTIAL FORCES



SUMMATION OF NORMAL FORCES

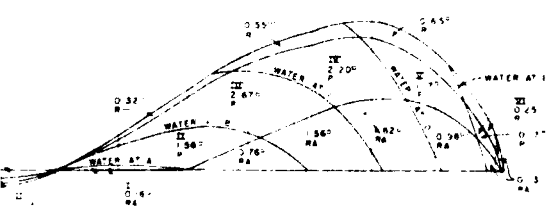
HORIZONTAL SCALE IN FEET 0 60 120

VERTICAL SCALE IN FEET 0 10 20



[illegible]BANKMENT SECTION

[illegible]CALE IN FEET [illegible] 60 120



SUMMATION OF TANGENTIAL FORCES

HORIZONTAL SCALE IN FEET

VERTICAL SCALE IN FEET

UNIT WEIGHTS, PCF

MATERIAL	γ_{DRY}	γ_{MOIST}	γ_{SUB}
DUMPED ROCK	100		59
RANDOM FILL		35	76
PERVIOUS FILL		140	86

LEGEND

R = DUMPED ROCK
RA = RANDOM FILL
P = PERVIOUS FILL

RIO GRANDE WATERSHED RIO CHAMA, NEW MEXICO
ABIQUIU DAM AND RESERVOIR

STABILITY ANALYSIS—UPSTREAM SLOPE VARIATION OF SAFETY FACTOR WITH POOL ELEVATION

SCALE AS SHOWN

ALBUQUERQUE DISTRICT, ALBUQUERQUE, N.M.

TO ACCOMPANY DESIGN MEMORANDUM FILE NO
ON EMBANKMENT AND SPILLWAY
DATED MAY 1958 RG-CH-G-24/12

CORPS OF ENGINEERS

MATERIAL	UNIT WEIGHT, PCF				SHEAR STRENGTH CD (DS)	
	γ_{SAT}	γ_{MOIST}	γ_{DRY}	γ_{SUB}	ϕ	C, PSF
DUMPED ROCK			100		35°	0
PERVIOUS FILL	148	140		86	35°	0
IMPERVIOUS FILL	134	130		72	25°	0
RANDOM FILL		135			27°	0
STREAMBED ALLUVIUM	148			86	35°	0
CLAY, SHALE, ETC				86	20°	0

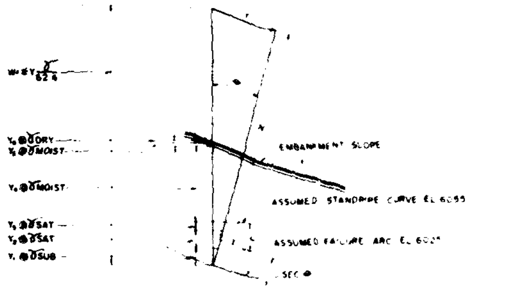
RESISTING FORCES

AREA, S.F.	N, KIPS	ϕ	TAN ϕ	N TAN ϕ, KIPS
11,232	700.9	35°	.700	490.6
1,152	71.9	35°	.700	50.3
14,256	889.6	27°	.510	453.7
55,764	3,479.7	20°	.364	1,266.6
			ΣN TAN ϕ =	2,261.2

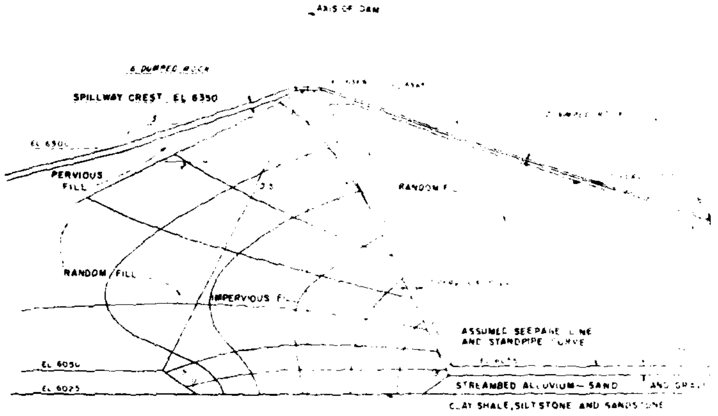
DRIVING FORCES

AREA, S.F.	T, KIPS
+31,788	1,983.6
− 5,796	− 361.7
	ΣT = 1,621.9

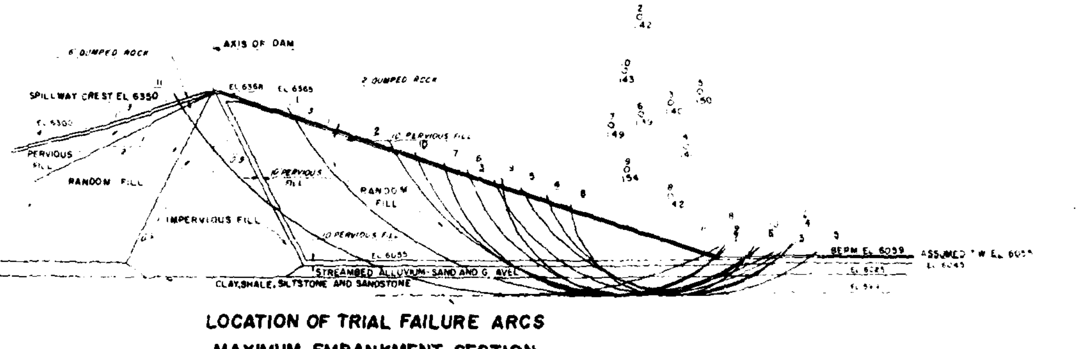
$$\text{SAFETY FACTOR} = \frac{\Sigma N \tan\phi}{\Sigma T} = \frac{2{,}261.2}{1{,}621.9} = 1.39$$



TYPICAL VECTOR DIAGRAM



MAXIMUM EMBANKMENT

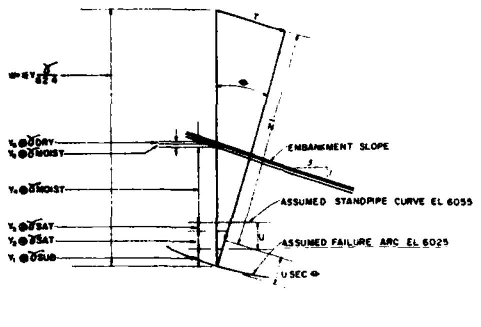


LOCATION OF TRIAL FAILURE ARCS

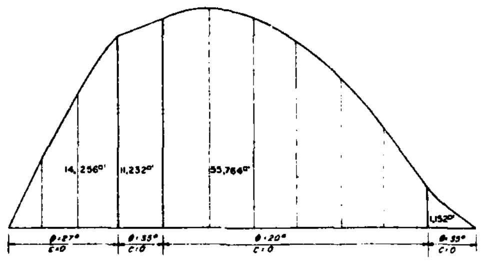
MAXIMUM EMBANKMENT SECTION

SCALE IN FEET

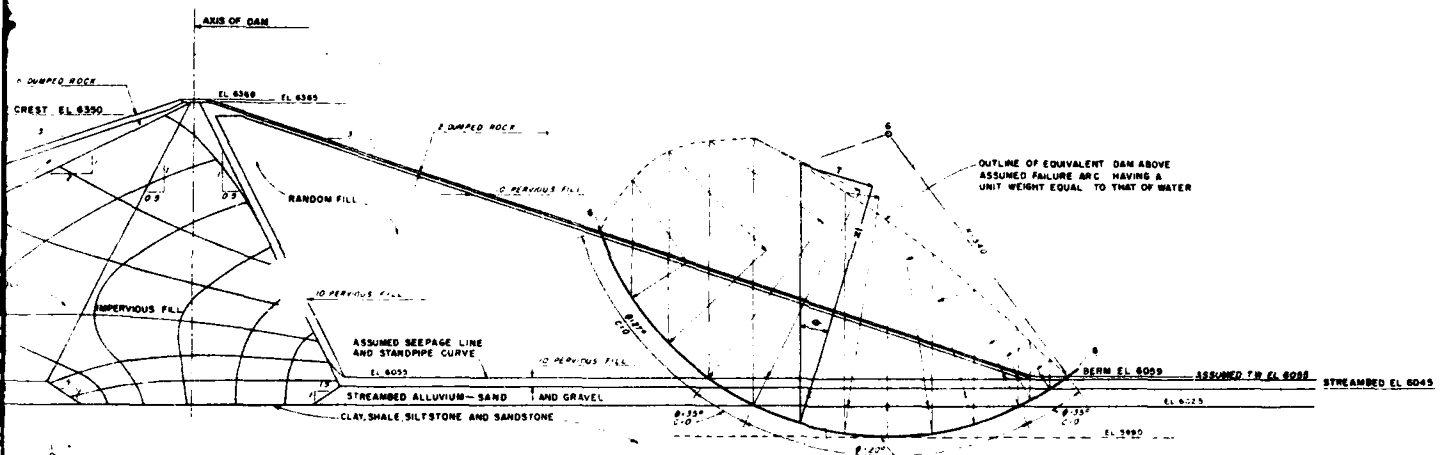
U.S. ARMY



TYPICAL VECTOR DIAGRAM

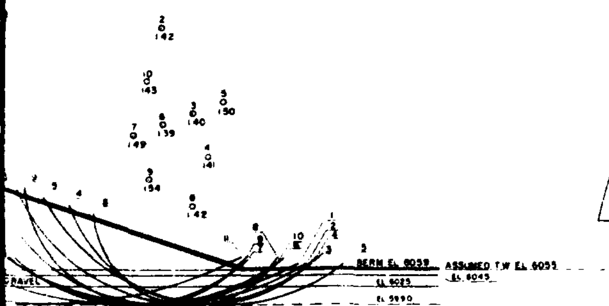


SUMMATION OF NORMAL FORCES



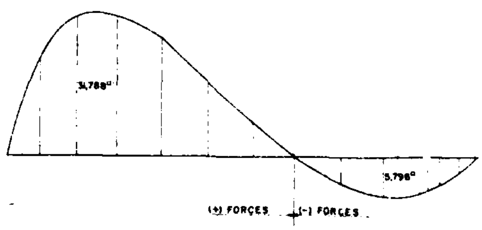
MAXIMUM EMBANKMENT SECTION

SCALE IN FEET



ARCS

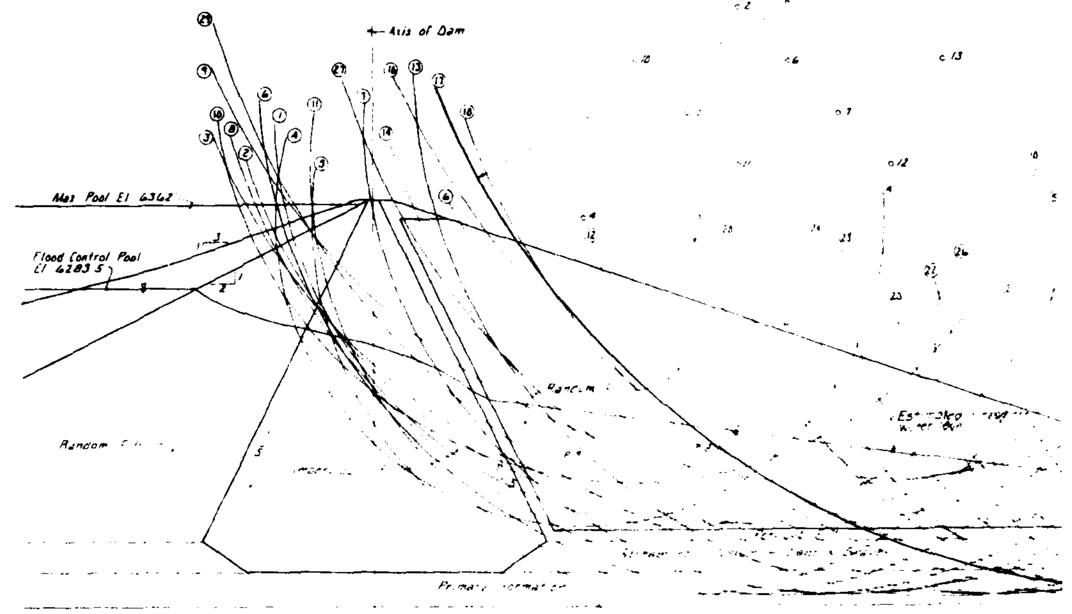
TION



SUMMATION OF TANGENTIAL FORCES

RIO GRANDE WATERSHED — RIO CHAMA, NEW MEXICO ABIQUIU DAM AND RESERVOIR	
STABILITY ANALYSIS—DOWNSTREAM SLOPE POST CONSTRUCTION CONDITION WITH SEEPAGE	
SCALE AS SHOWN	
ALBUQUERQUE DISTRICT, ALBUQUERQUE, N.M.	
TO ACCOMPANY DESIGN MEMORANDUM ON EMBANKMENT AND SPILLWAY DATED MAY 1958	FILE NO. RG-CH-G-24/14

Arc	X	Y	R		F S
1	300	82	394		2.96
2	350	182	494		2.59
3	400	282	594		2.38
4	200	-18	294		4.40
5	300	-18	360		3.54
6	400	132	510		2.55
7	450	82	460		2.50
8	450	232	610		2.32
9	450	382	656		2.24
10	250	132	403		3.20
11	350	32	300		2.98
12	300	32	300		2.56
13	330	132	311		2.21
14	600	232	611		2.01
15	700	332	714		1.80
16	800	482	864		1.74
17	770	382	764		1.73
18	733	300	682		1.77
19	790	142	520		1.75
20	850	-15	360		1.75
21	880	-100	275		1.81
22	908	5	380		1.77
23	793	-40	340		1.90
24	738	-60	318		2.14
25	850	-190	185		2.08
26	770	-140	232		2.32
27	650	332	713		1.86
28	763	45	430		1.85
29	585	390	730		N.G.

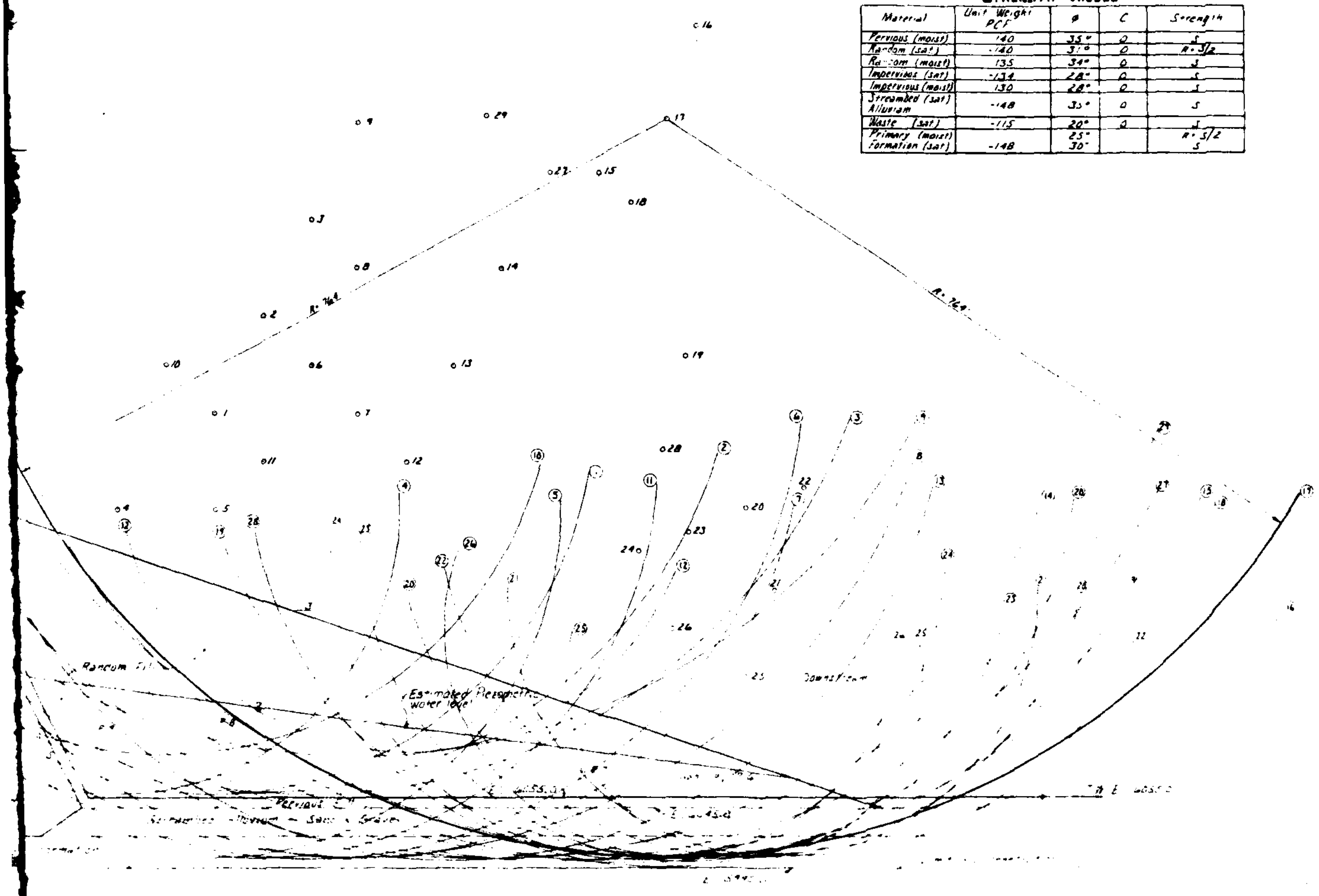


LOCATION OF TRIAL FAILURE ARCS

MAXIMUM EMBANKMENT SECTION

STRENATH VALUES

Material	Unit Weight PCF	φ	C	Strength
Pervious (moist)	140	35°	0	S
Random (sat)	140	31°	0	R+S/2
Random (moist)	135	34°	0	S
Impervious (sat)	134	28°	0	S
Impervious (moist)	130	28°	0	S
Streambed (sat) Alluvium	148	35°	0	S
Waste (sat)	115	20°	0	S
Primary (moist) Formation (sat)	148	25° 30°		R+S/2 S



LEGEND

P.B. Piezometer

LOCATION OF TRIAL FAILURE ARCS

MAXIMUM EMBANKMENT SECTION

ARMY ENGINEER DISTRICT ALBUQUERQUE

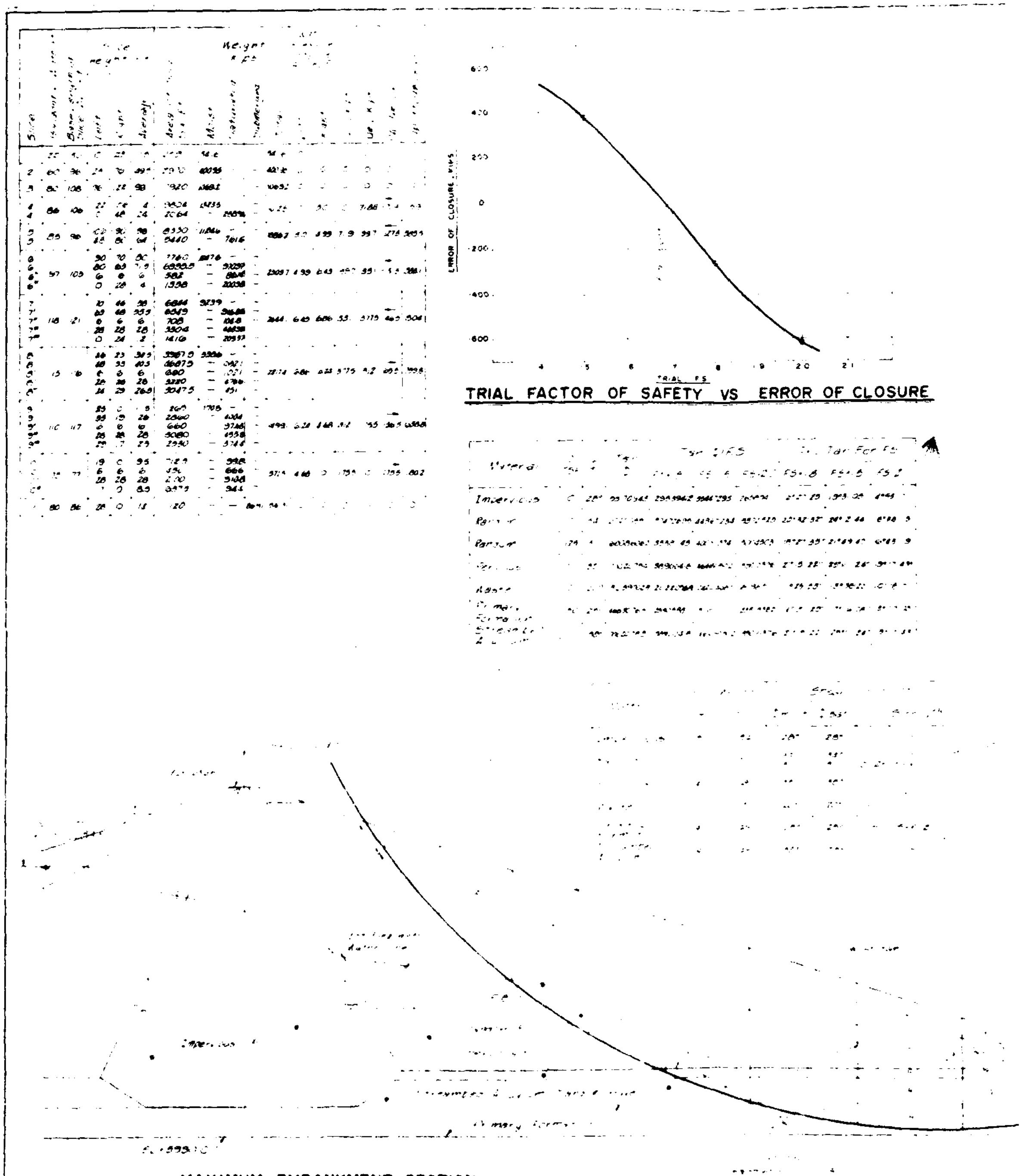
RIO GRANDE WATERSHED RIO CHAMA NEW MEXICO

ABIQUIU DAM AND RESERVOIR

STABILITY ANALYSIS DOWNSTREAM SLOPE
STEADY SEEPAGE CONDITION

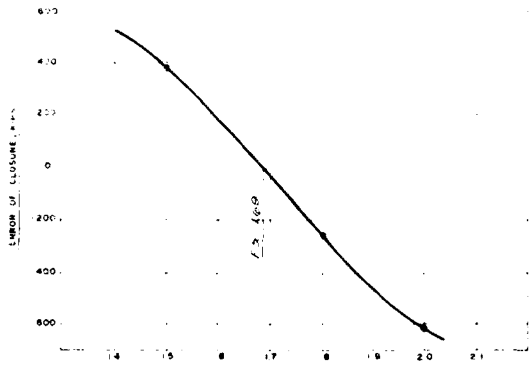
COMPUTER SOLUTION

PLATE 26



TRIAL FACTOR OF SAFETY VS ERROR OF CLOSURE

MAXIMUM EMBANKMENT SECTION

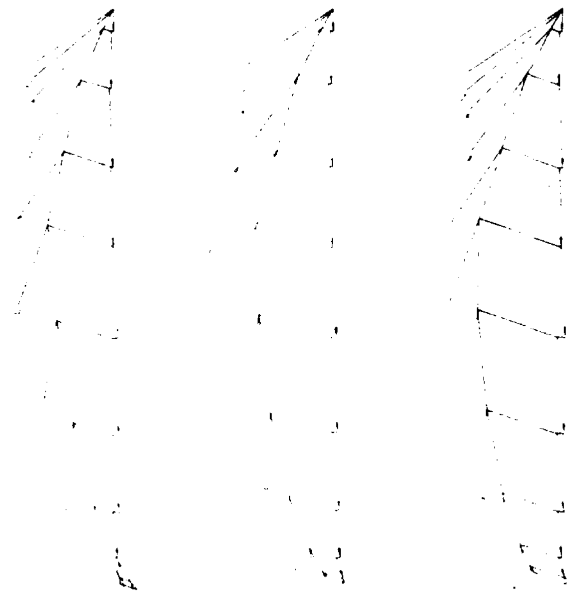


TRIAL FACTOR OF SAFETY VS ERROR OF CLOSURE

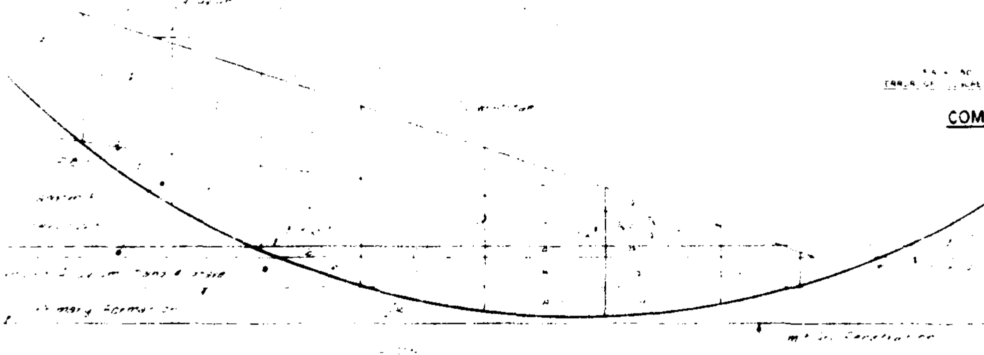
Material	C TSF	Ø	Tan Ø	Tan Ø/FS FS=1.6	Tan Ø/FS FS=1.8	Tan Ø/FS FS=2.0	Ø for FS FS=1.6	Ø for FS FS=1.8	Ø for FS FS=2.0
Impervious	0	28°	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	34°	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	0	20°	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Primary Formation	[illegible]	25°	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Material	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Impervious	[illegible]	[illegible]	28°	28°	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]		[illegible]	[illegible]	[illegible]	
Primary Formation	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	

RESULTANT OF WEIGHT AND WATER FORCES ON SLICE



COMPOSITE FORCE POLYGONS



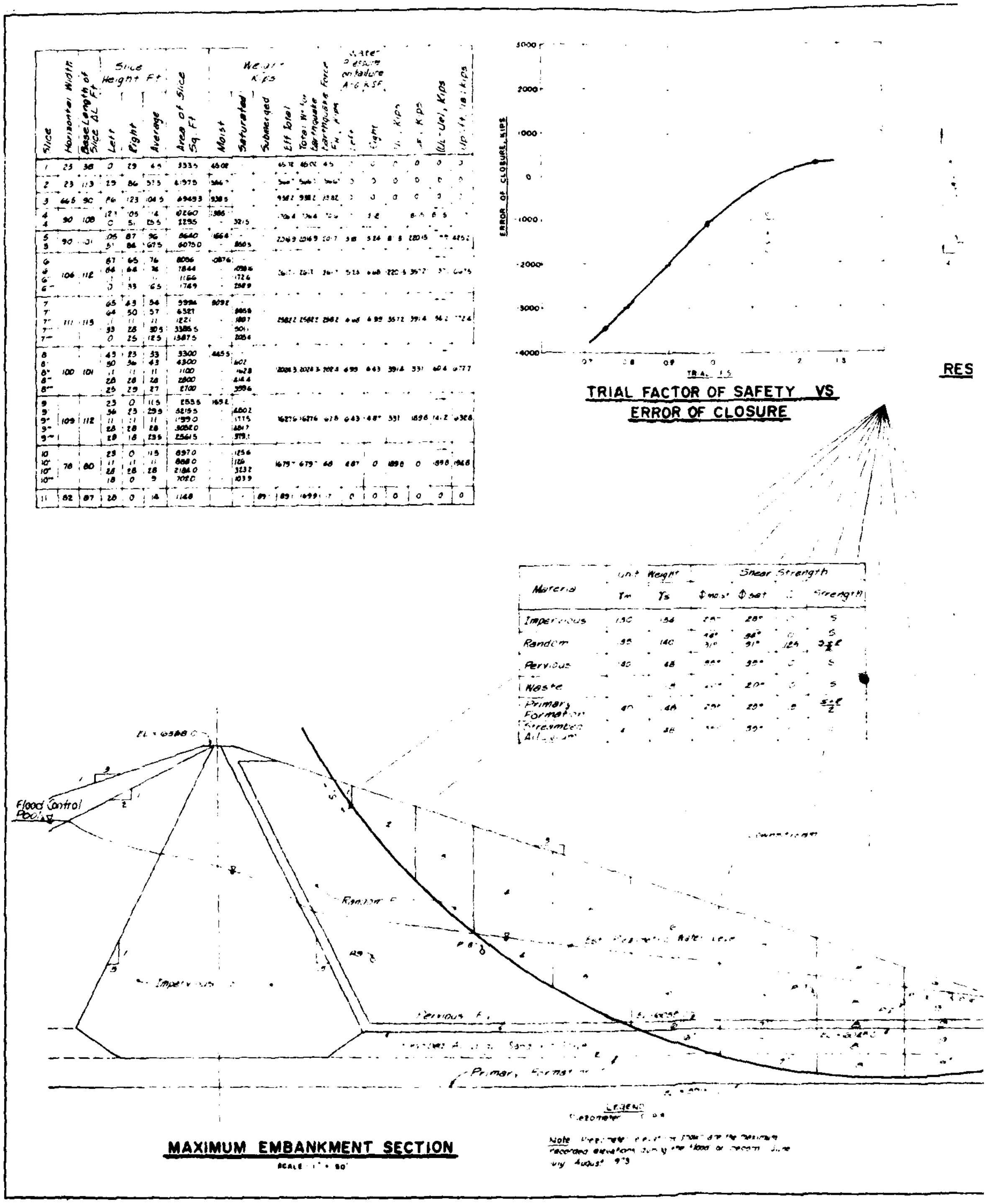
CTION

ABIQUIU DAM AND RESERVOIR

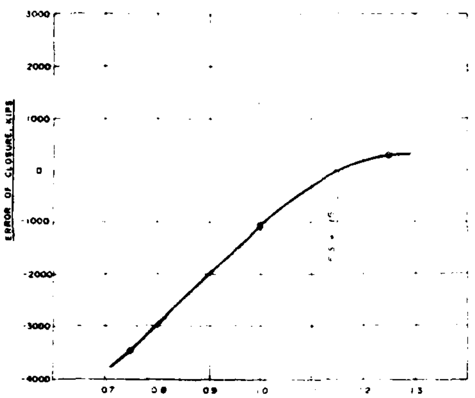
RIO CHAMA, NEW MEXICO

STABILITY ANALYSIS - DOWNSTREAM SLOPE
STEADY SEEPAGE CONDITION
MANUAL SOLUTION

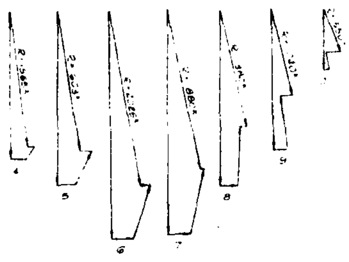
US ARMY ENGINEER DISTRICT, ALBUQUERQUE, N.M.
FILE NO.



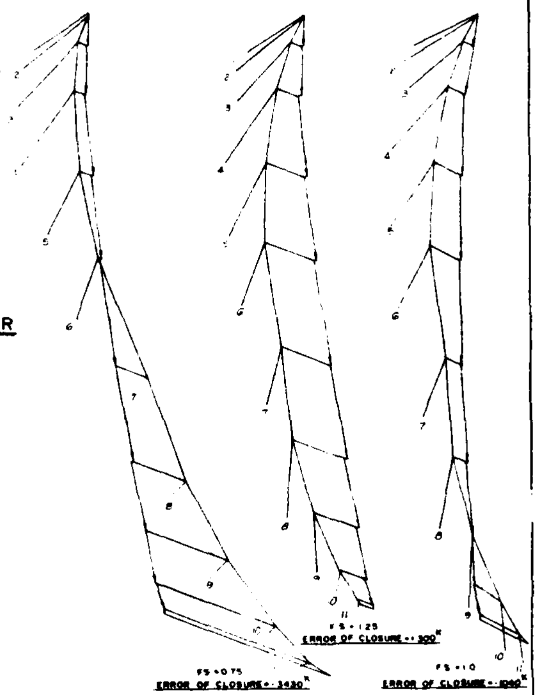
Slice
Horizontal Width
Base Length of Slice ΔL Ft
Slice Height Ft
Left
Right
Average
Area of Slice Sq Ft
Weight Kips
Moist
Saturated
Submerged
ERROR OF CLOSURE, KIPS
TRIAL FACTOR OF SAFETY VS ERROR OF CLOSURE
RES
Material
Unit Weight
Shear Strength
Impervious
Random
Pervious
Waste
Primary Formation
Flood Control Pool
Random Fill
Impervious
Pervious Fill
Primary Formation
Legend
Piezometer
MAXIMUM EMBANKMENT SECTION
Note



TRIAL FACTOR OF SAFETY VS ERROR OF CLOSURE



RESULTANT OF WEIGHT & WATER FORCES ON SLICE
SCALE: 1" = 600^k

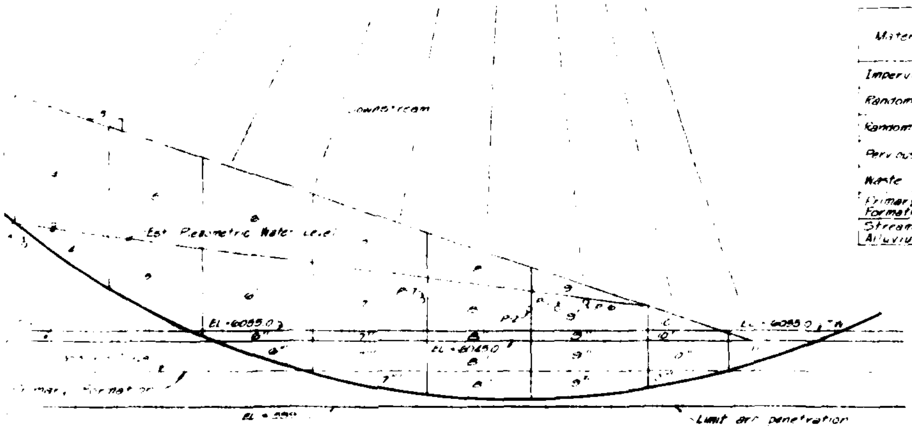


COMPOSITE FORCE POLYGONS
SCALE: 1" = 1000^k

Note
Stability Analysis in accordance with E.M. 1110-2-1902, Stability of Earth and Rockfill Dams, 1 April 1970.

Material	Unit Weight γ_m	Unit Weight γ_s	Shear Strength Φ moist	Shear Strength Φ sat	Shear Strength C	Shear Strength Strength
Impervious	130	134	2[illegible]°	28°	0	S
Random	135	140	34° 31°	34° 31°	0 .125	S $\frac{S+R}{2}$
Pervious	140	148	[illegible]	3[illegible]°	0	S
Waste		115	[illegible]	20°	0	S
Primary Formation	140	148	2[illegible]°	25°	.5	$\frac{S+R}{2}$
Streambed Alluvium	140	148	[illegible]	35°	[illegible]	[illegible]

Material	C TSF	Φ	Tan Φ	Tan Φ / F.S. FS=.75	FS=1.25	FS=1.00	Arc Tan For F.S. FS=.75	FS=1.25	FS=1.00
Impervious	0	28°	.53170943	.70894590	[illegible]	.53170943	35°20'0[illegible]"	23°02'[illegible]"	28°
Random	b	34°	.67450851	[illegible]	[illegible]	.6745085	41°57'59"	[illegible]°21'06"	34°
Random	.125	31°	.60086062	.8011749	[illegible]	.60086062	38°42'00"	25°40'23"	31°
Pervious	0	35°	.70020754	.9336[illegible]005	.56016603	.70020754	43°02'01"	29°15'22"	35°
Waste	0	20°	.36397023	[illegible]	.2911[illegible]	.36397023	2[illegible]°[illegible]'15"	16°[illegible]'0[illegible]"	20°
Primary Formation	.50	25°	.46630765	.62[illegible]	.37304612	.46630765	31°5[illegible]'1[illegible]"	20°27'[illegible]"	25°
Streambed Alluvium	0	35°	.70020754	.9336[illegible]005	.56016603	.70020754	43°02'01"	29°15'22"	35°



LEGEND
Piezometer ○ P-4

Note: Piezometer elevations shown are the maximum recorded elevations during the flood of record. June-July, August 1973.

RIO GRANDE WATERSHED — RIO CHAMA, NEW MEXICO

ABIQUIU DAM AND RESERVOIR

STABILITY ANALYSIS - DOWNSTREAM SLOPE EARTHQUAKE CONDITION WITH SEEPAGE

MANUAL SOLUTION

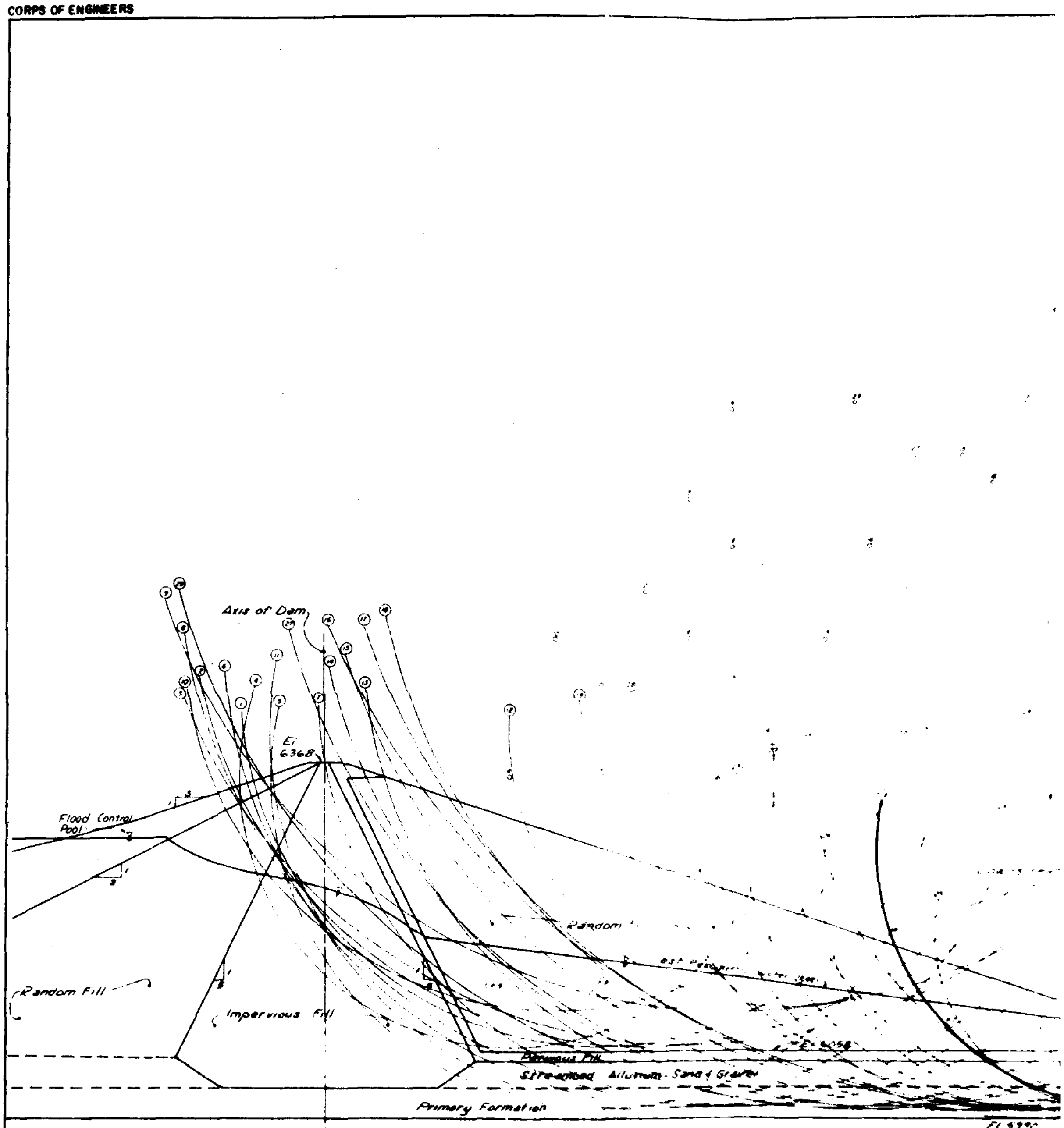
US ARMY ENGINEER DISTRICT, ALBUQUERQUE, N.M.

FILE NO.

TO ACCOMPANY PERIODIC INSPECTION REPORT NO. [illegible]

DATE: OCT 1976

CORPS OF ENGINEERS



Legend
Piezometer ◦ P-8
Note: Piezometer elevations shown are the maxium elevations recorded during the flood of Record, June July Aug '73

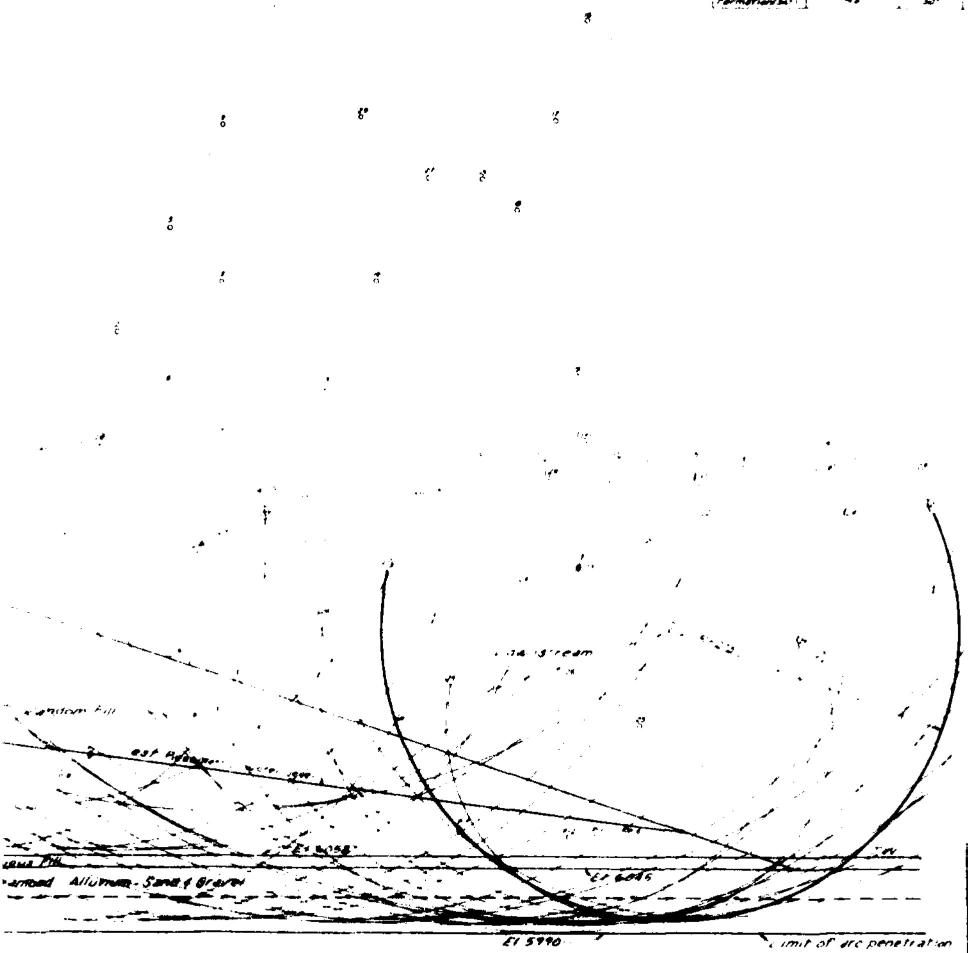
LOCATION OF TRAIL FAILURE ARCS

MAXIMUM EMBANKMENT SECTION

STRENGTH VALUES

Material	Unit Weight pcf	φ	c	Strength
Pervious (shell)	140	35°	0	S
Random (dry)	140	31°	0	R+S/2
Random (wet)	135	34°	0	S
Impervious	130	28°	0	R
Impervious	[illegible]	28°	0	R
Streambed Alluvium	148	35°	0	S
Waste	[illegible]	40°	0	S
Primary Formation	148	35° / 30°	0	R+S/2 / S

Arc	x	y	R	F.S.
1	300	[illegible]	[illegible]	.64
2	350	82	[illegible]	.68
3	400	151	594	.63
4	[illegible]	8	[illegible]	.84
5	300	8	360	.97
6	[illegible]	33	[illegible]	.37
7	450	82	[illegible]	[illegible]
8	[illegible]	[illegible]	[illegible]	[illegible]
9	[illegible]	382	640	[illegible]
10	250	[illegible]	[illegible]	[illegible]
11	350	[illegible]	[illegible]	[illegible]
12	400	[illegible]	[illegible]	[illegible]
13	[illegible]	[illegible]	[illegible]	[illegible]
14	[illegible]	[illegible]	[illegible]	[illegible]
15	700	[illegible]	[illegible]	[illegible]
16	[illegible]	[illegible]	[illegible]	[illegible]
17	770	[illegible]	[illegible]	[illegible]
18	733	[illegible]	[illegible]	[illegible]
19	[illegible]	[illegible]	[illegible]	[illegible]
20	[illegible]	[illegible]	[illegible]	[illegible]
21	[illegible]	[illegible]	376	[illegible]
22	[illegible]	5	[illegible]	[illegible]
23	773	[illegible]	[illegible]	[illegible]
24	[illegible]	[illegible]	[illegible]	[illegible]
25	[illegible]	[illegible]	[illegible]	[illegible]
26	770	[illegible]	[illegible]	[illegible]
27	[illegible]	[illegible]	[illegible]	.77
28	[illegible]	[illegible]	[illegible]	[illegible]
29	[illegible]	[illegible]	[illegible]	[illegible]



'ION OF TRAIL FAILURE ARCS

M EMBANKMENT SECTION

SCALE 1" = 60'-0"

Note: Computer Solution by the use of the Simplified Bishop Analysis Programmed for the GE 225 Computer. Geotechnique Vol V No 1, 1955 March 1955 A.W. Bishop

RIO GRANDE WATERSHED — RIO CHAMA NEW MEXICO

ABIQUIU DAM AND RESERVOIR

STABILITY ANALYSIS, DOWNSTREAM SLOPE EARTHQUAKE CONDITION WITH SEEPAGE

COMPUTER SOLUTION

US ARMY ENGINEER DISTRICT, ALBUQUERQUE, N M

FILE NO

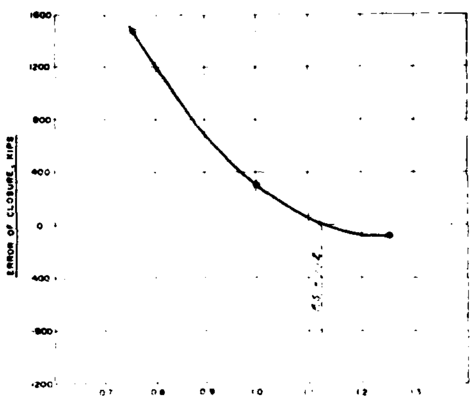
DATE OCT 1970 — RGAB-PI-1

2

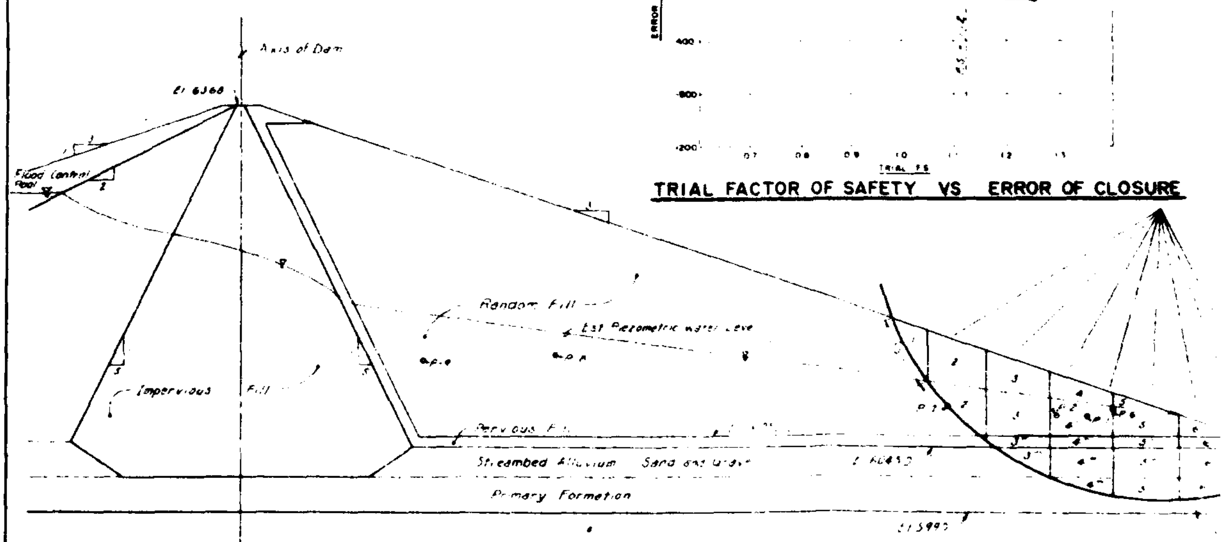
Slice	Horizontal Width, Ft	Base Length of Slice ΔL, Ft	Slice Height Ft Left	Right	Average	Area of Slice Ft²	Weight Kips Moist	Saturated	Submerged	Effective Total	Total Wt for Earth [illegible]	Driving Force F, Kips	Water Pressure [illegible] Left	Right	U_L, Kips	U_R, Kips	(U_L-U_R), Kips	Uplift, Ue, Kips
1	35	70	0	48	24	840	1134	-	-	1134	1134	34	0	0	0	0	0	0
2	55	80	48	38	43	2365	3193	-	—	5118	5118	5110	0	3.12	0	19	18	.48
2			0	50	25	1375	—	1925	—									
3	40	70	30	25	[illegible]	1890	2552	—	—	8026	8026	84.3	3.12	4.14	78	.118	99.8	115[illegible]
3			50	37	43.5	2610	—	3654	—									
3'			11	11	11	660	—	911	—									
3"			0	28	14	840	—	1243	—									
4	60	63	25	13	19	1160	1559	—	—	8532	8532	85.3	4.14	6.12	.118	2996	-218	345[illegible]
4			37	28	32.5	1950	—	273	—									
4'			11	11	11	660	—	911	—									
4"			28	28	28	1680	—	2406	—									
4'"			0	18	9	540	—	799	—									
5	61.5	62	13	0	6.5	399.75	5397	—	—	7928	7928	79.3	6.12	4.99	2996	1997	9992	304.4
5			28	21	24.5	1506.75	—	2010	—									
5'			11	11	11	676.5	—	1001	—									
5"			28	28	28	1722.0	—	2549	—									
5'"			18	20	19	1168.5	—	1729	—									
6	61.5	63	21	0	10.5	665.79	—	9841	—	5896	5896	58.2	.499	0	1997	0	1997	157.2
6			11	11	11	676.5	—	1001	—									
6'			28	28	28	1722.0	—	2549	—									
6"			20	10	15	922.5	—	1365	—									
7	31	34	11	0	5.5	170.5	—	—	132	928	176.6	17.7	0	0	0	0	0	0
7			28	28	28	868	—	—	674									
7'			10	0	5	155	—	—	120									
8	49	57	28	0	14	686	—	—	532.3	532.3	101.53	10.2	0	0	0	0	0	0

Material	c	φ	[illegible]	Tan φ / F.S. FS=1.25	FS=1.1	FS=0.75	FS=1.25	Arc Tan for F.S.		
Impervious	[illegible]	28	.5317094	[illegible]	.42536754	[illegible]	31°20'05"	[illegible]	[illegible]
Random	[illegible]	34°	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	34°
Random	[illegible]	31°	[illegible]	.8014749	.48068849	[illegible]	38°42'00"	25°41'25"	31°
Pervious	[illegible]	35°	[illegible]	.93361005	.56016603	.70028754	41°02'01"	29°15'22"	35°
Waste	[illegible]	20°	[illegible]	.48529364	.29117618	.36397023	25°53'13"	[illegible]	20°
Primary Formation	[illegible]	25°	.46630765	[illegible]	.31304612	.46630765	31°52'16"	20°2'[illegible]	25°
Streambed Alluvium	0	35°	.70028754	.93361005	.56016603	.70028754	43°02'01"	29°15'22"	35°

Material	Unit Weight γ_m	γ_s	Shear Strength ϕ moist	ϕ sat	C	Strength
Impervious	130	134	28°	28°	0	S
Random	135	140	34° 31°	34° 31°	0 0.125	S $\frac{S+R}{2}$
Pervious	140	148	35°	35°	0	S
Waste		115	20°	20°	0	S
Primary Formation	140	148	25°	25°	0.5	$\frac{S+R}{2}$
Streambed Alluvium	140	148	35°	35°	0	S



TRIAL FACTOR OF SAFETY VS ERROR OF CLOSURE



MAXIMUM EMBANKMENT SECTION

Legend

Piezometer ● P.8

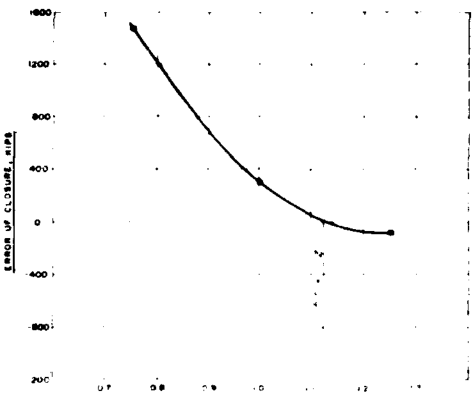
Note: Piezometer elevations shown are the maximum record elevations during the flood of record June, July, August 1973

Note

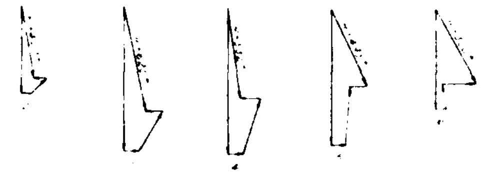
Stability Analysis in a[illegible] EM 1110-2-1902 Stabili[illegible] and Rock Fill Dams, Ap[illegible]

Material					Arc Tan for F.S.	
Impervious	28°	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Random	34°	[illegible]	[illegible]	[illegible]	[illegible]	34°
Random	31°	[illegible]	[illegible]	[illegible]	38°42'30" 25°4'35"	[illegible]
Pervious	35°	[illegible]	[illegible]	[illegible]	41°02'01" 29°5'22"	35°
Waste	20°	[illegible]	[illegible]	[illegible]	[illegible]	20°
Primary Formation	25°	[illegible]	[illegible]	[illegible]	31°52'16" [illegible] 28°	25°
Streambed Alluvium	35°	[illegible]	[illegible]	[illegible]	43°02'01" 29°[illegible] 22°	35°

Material	Unit weight γ_m	Unit weight γ_s	Shear Strength ϕ_{moist}	Shear Strength ϕ_{sat}	C	Strength
Impervious	130	14	28°	28°	0	S
Random	135	140	34° / 31°	34° / 31°	0 / 25	S / $\frac{S+R}{2}$
Pervious	140	148	35°	35°	0	S
Waste		115	20°	20°	0	S
Primary Formation	140	148	25°	25°	0.5	$\frac{S+R}{2}$
Streambed Alluvium	140	148	35°	35°	0	S

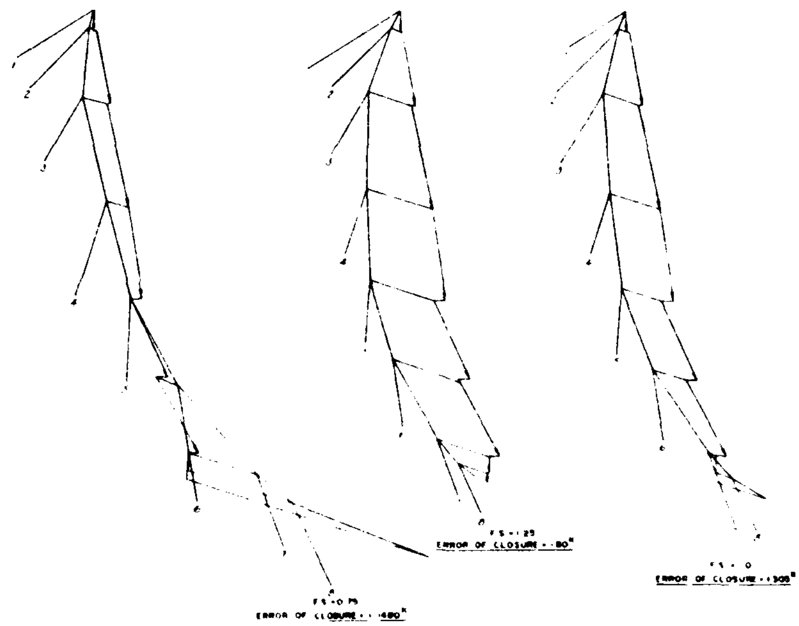


TRIAL FACTOR OF SAFETY VS ERROR OF CLOSURE



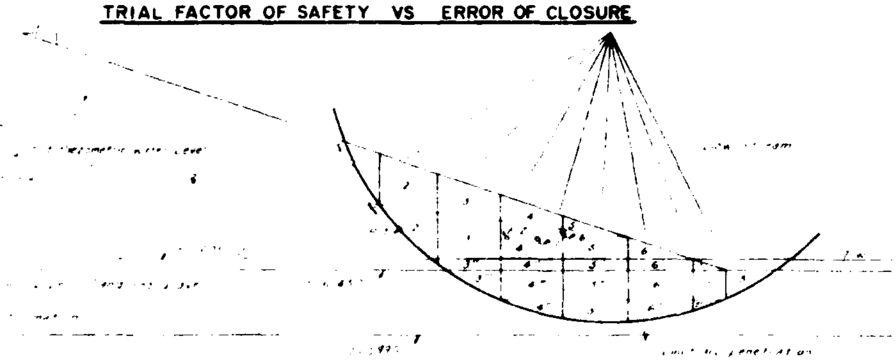
RESULTANT OF WEIGHT WATER AND EARTHQUAKE FORCES ACTING ON SLICE

SCALE 1" = 300^K



COMPOSITE FORCE POLYGONS

SCALE 1" = 300^K



Legend

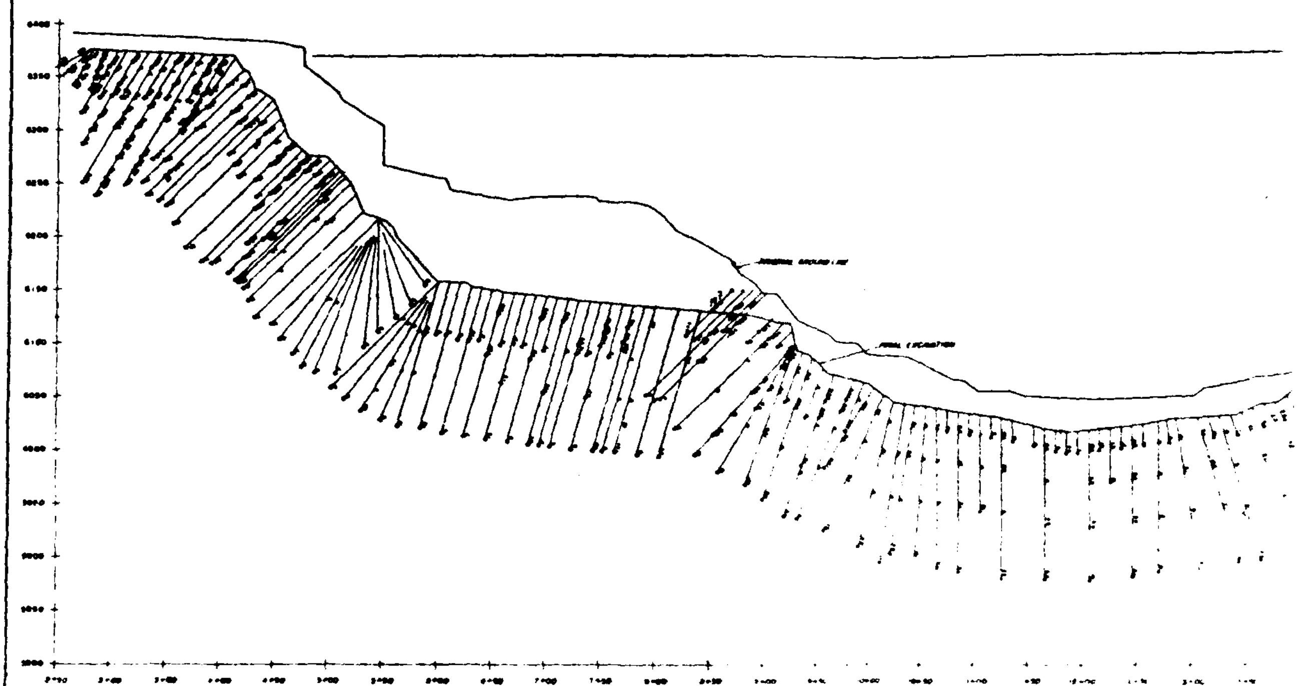
Note: Piezometer elevations shown are the maximum record elevations during the flood of record, [illegible] August 1973

Note

Stability Analysis in accordance with EM 1110-2-1902, Stability of Earth and Rock-Fill Dams, April 1970

RIO GRANDE WATERSHED	RIO CHAMA, NEW MEXICO
ABIQUIU DAM AND RESERVOIR	
STABILITY ANALYSIS - DOWNSTREAM SLOPE EARTHQUAKE CONDITION WITH SEEPAGE MANUAL SOLUTION	
US ARMY ENGINEER DISTRICT, ALBUQUERQUE, N M	FILE NO
DATE: OCT 1974	

CORPS OF ENGINEERS

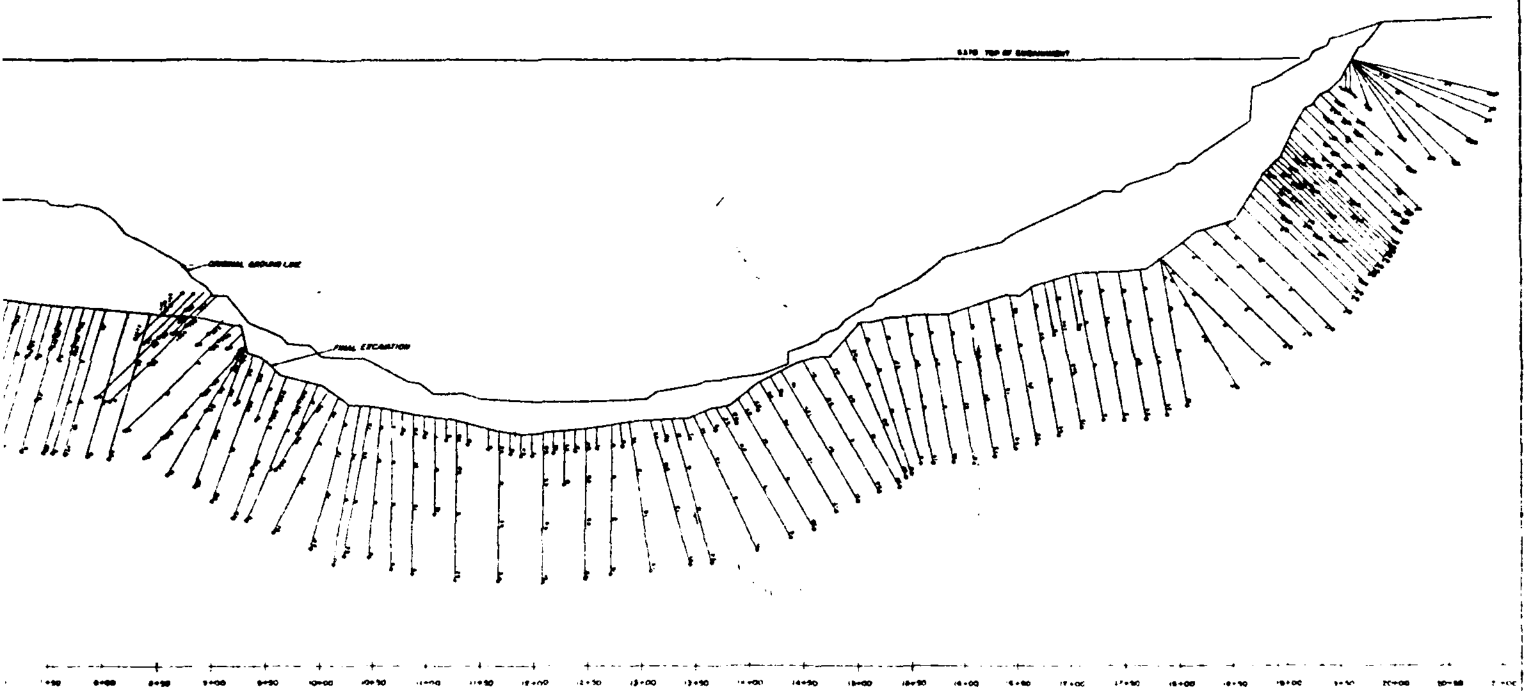


PROFILE ON AXIS OF EMBANKMENT

SHOWING LOCATION OF GROUT HOLES AND QUANTITIES OF GROUT

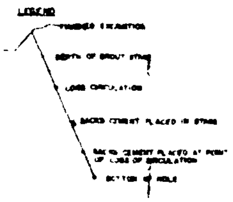
42

U.S. ARMY



PROFILE ON AXIS OF EMBANKMENT

SHOWING LOCATION OF GROUT HOLES AND QUANTITIES OF GROUT



RIO GRANDE WATERSHED — RIO CHAMA, NEW MEXICO
ABIQUIU DAM AND RESERVOIR

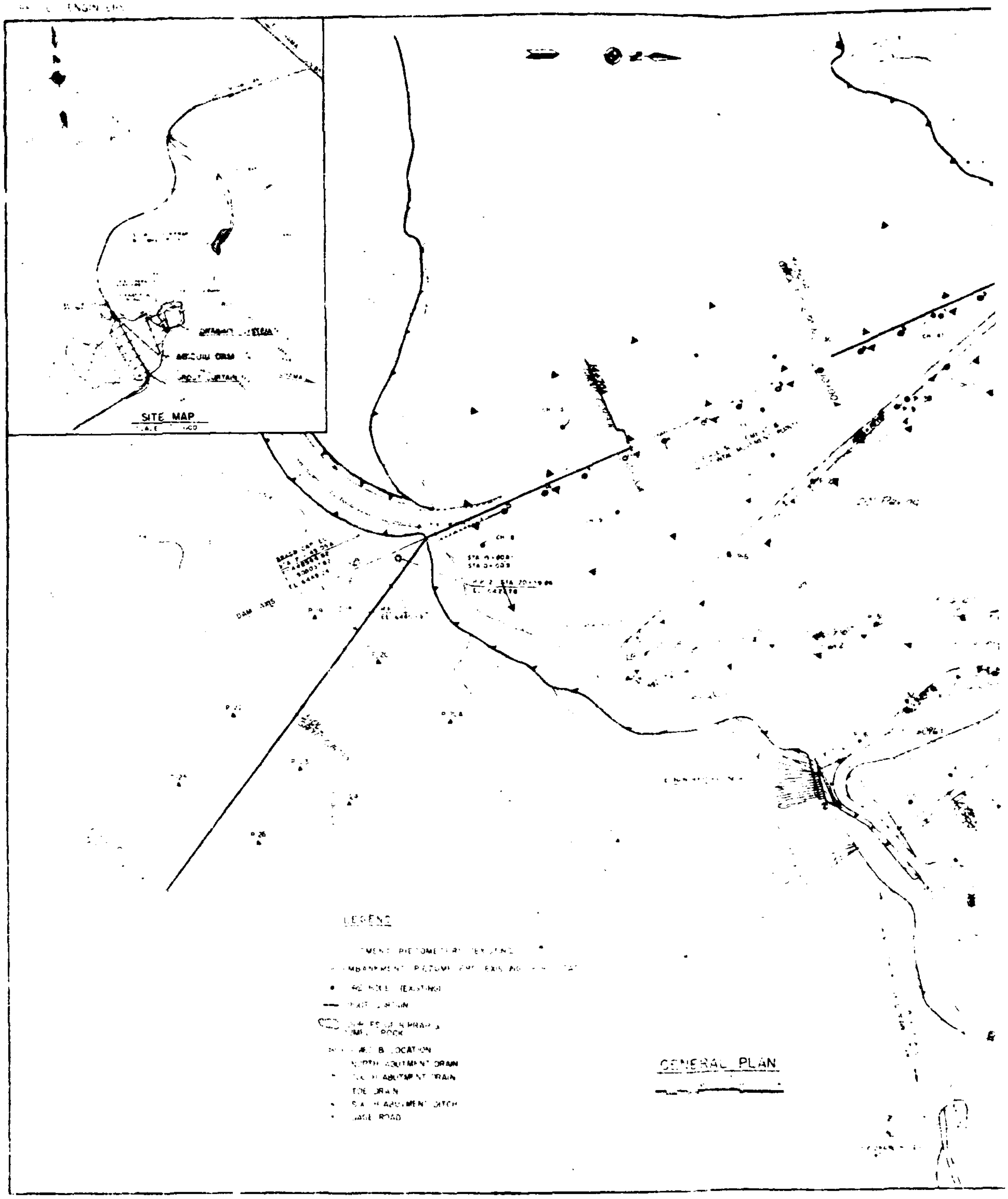
DETAILS OF GROUTING ETC.

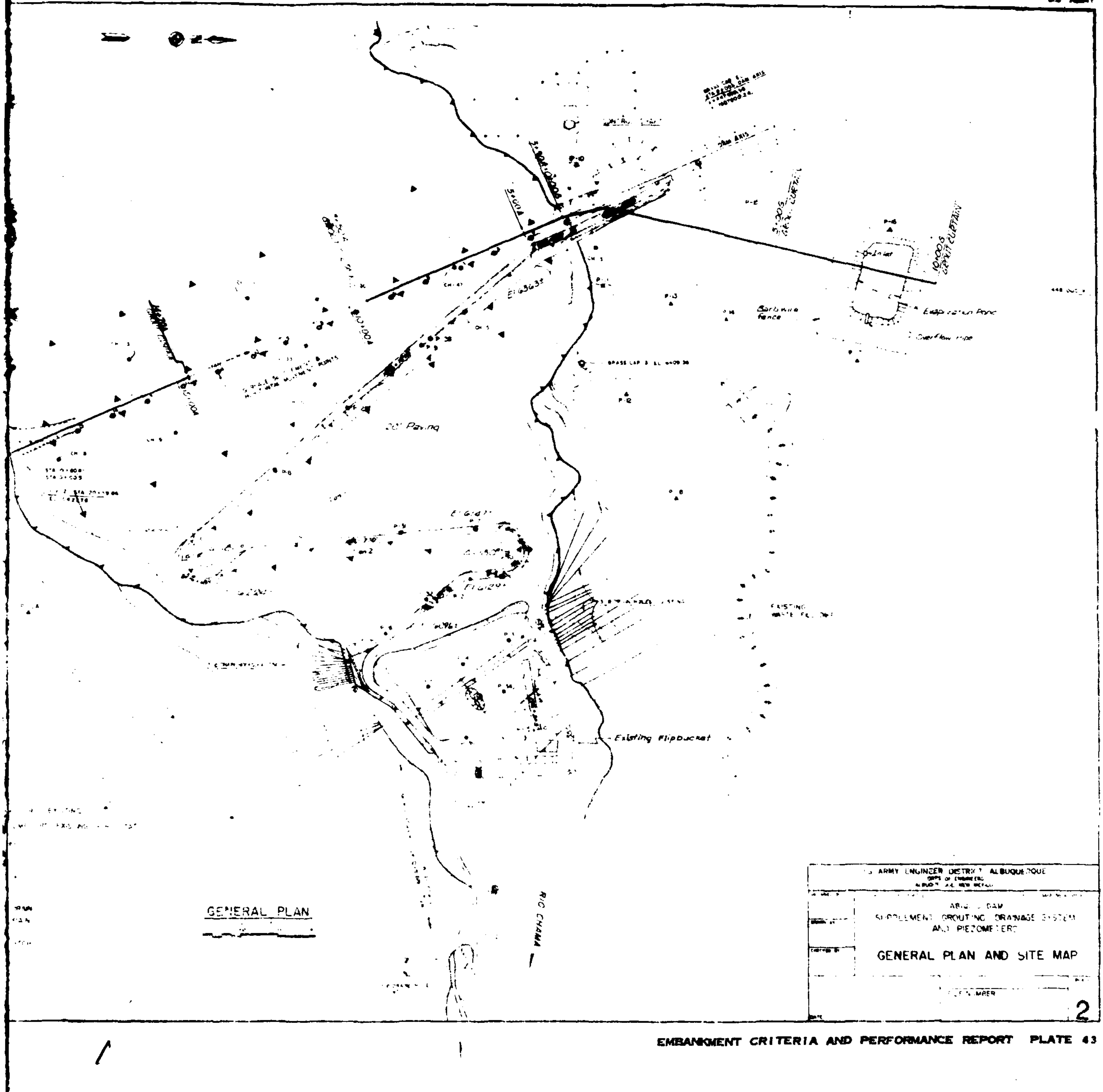
SCALE AS SHOWN

ALBUQUERQUE DISTRICT, ALBUQUERQUE, N.M.

TO ACCOMPANY FOUNDATION REPORT, EMBANKMENT AND SPILLWAY, ABIQUIU DAM AND RESERVOIR.

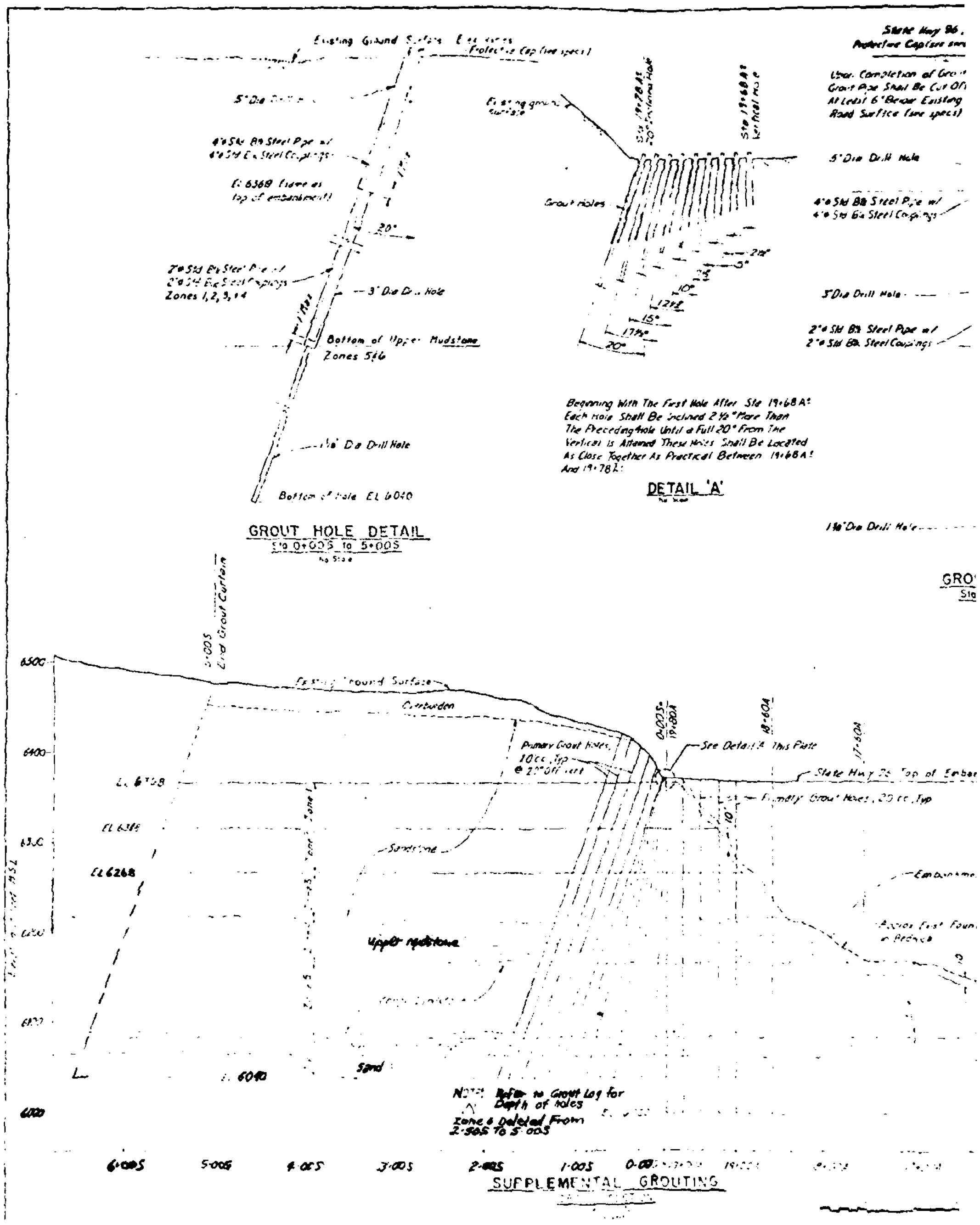
PLATE 3


SITE MAP
LEGEND
GENERAL PLAN

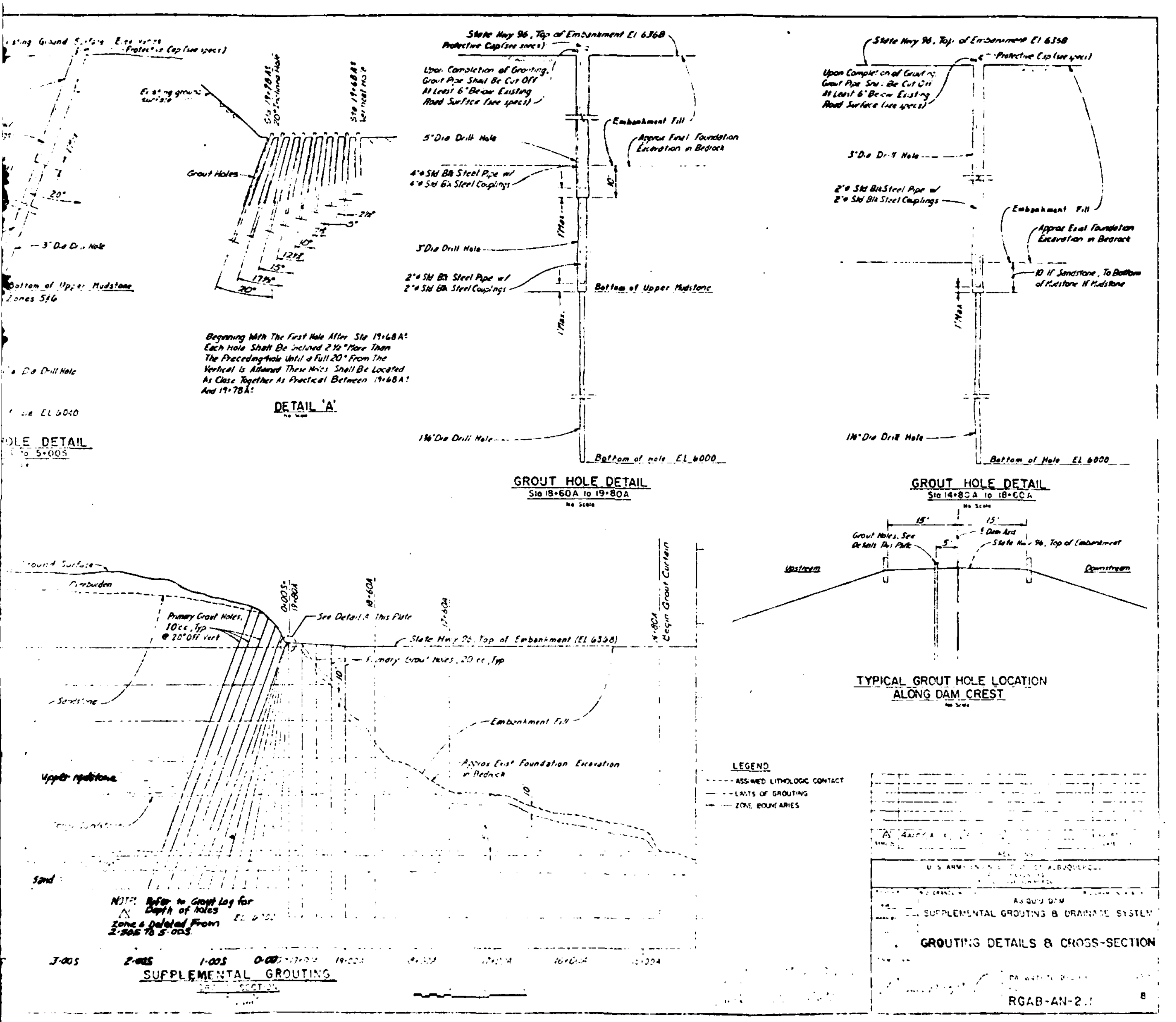

U.S. ARMY
20' Paving
Barb Wire Fence
Evaporation Pond
Overflow Pipe
GROUT CURTAIN
Existing Flipbucket
RIO CHAMA
GENERAL PLAN
U.S. ARMY ENGINEER DISTRICT, ALBUQUERQUE
CORPS OF ENGINEERS
ALBUQUERQUE, NEW MEXICO
ABIQUIU DAM
SUPPLEMENT GROUTING, DRAINAGE SYSTEM AND PIEZOMETERS
GENERAL PLAN AND SITE MAP
2

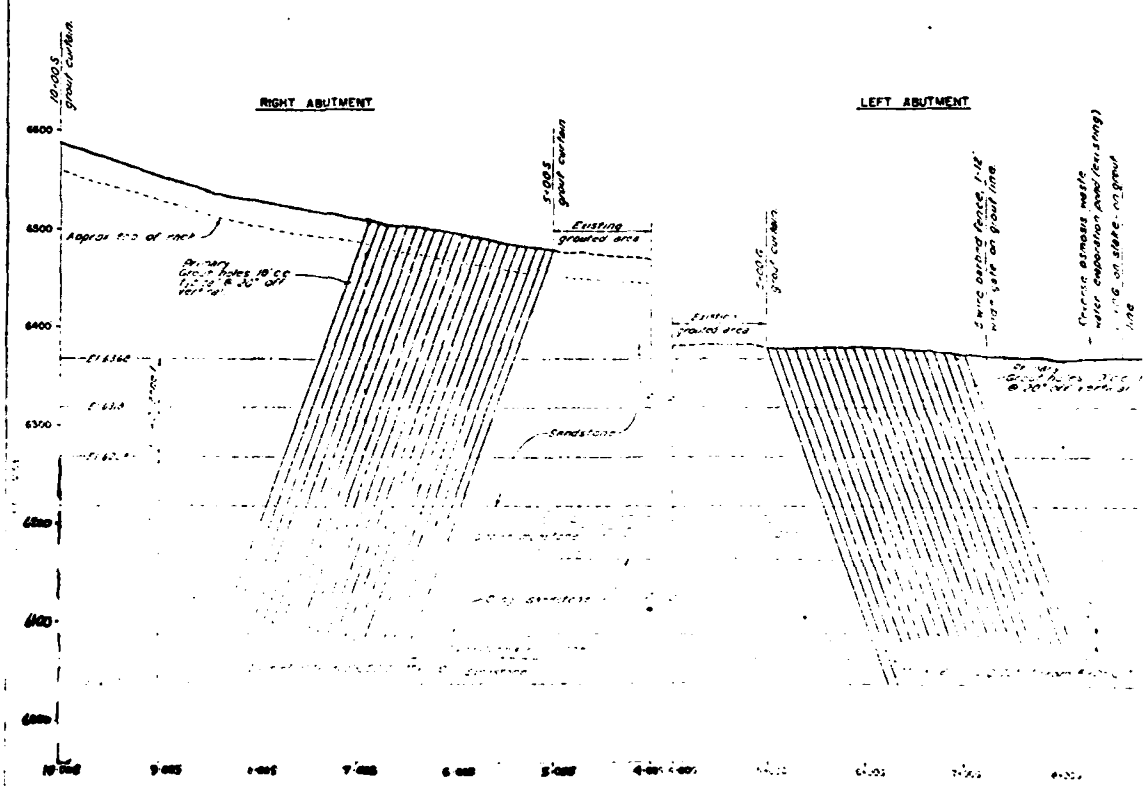
1

2



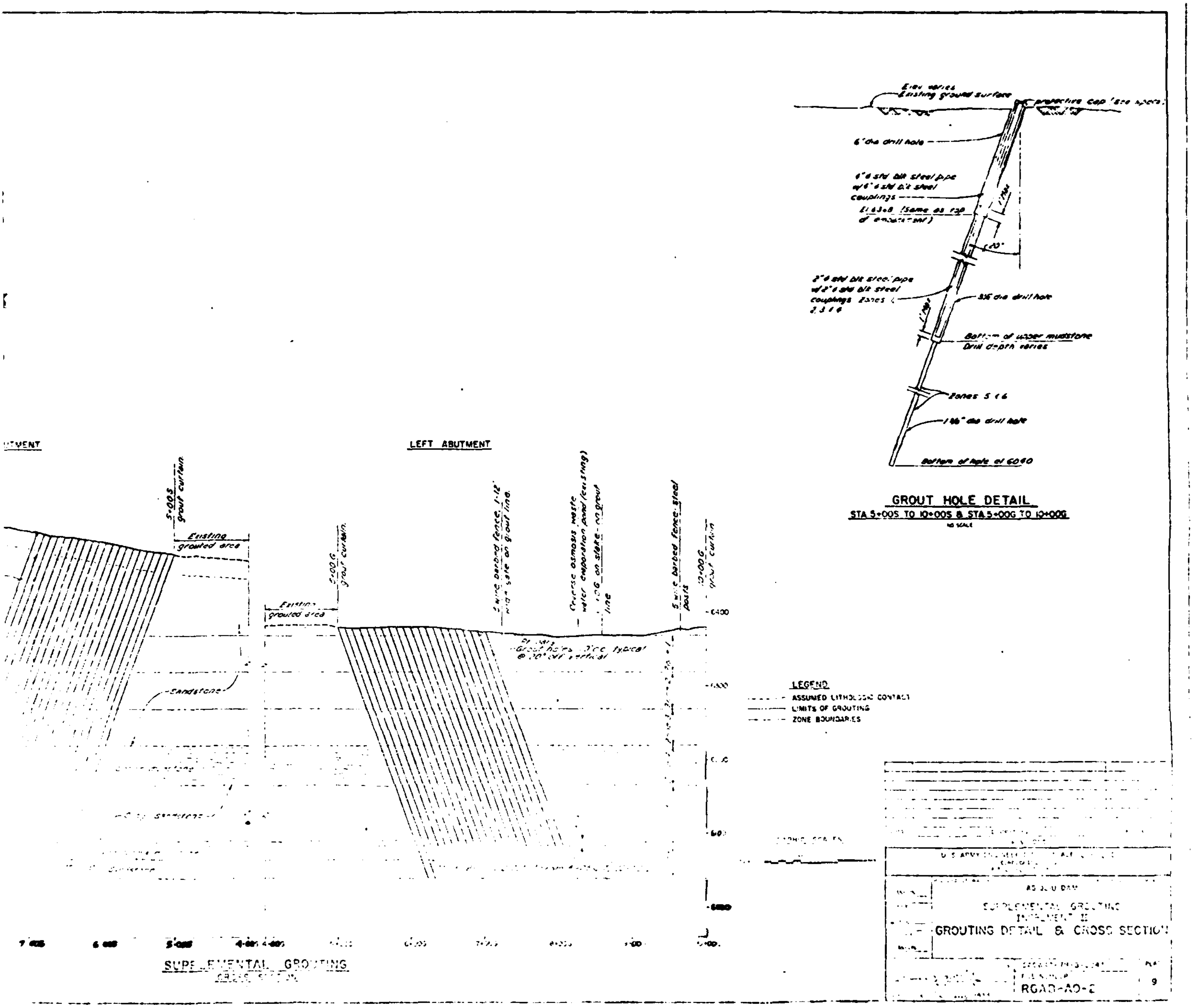
State Hwy 96.
Protective Cap (see spec)
Upon Completion of Grout, Grout Pipe Shall Be Cut Off At Least 6" Below Existing Road Surface (see specs)
Existing Ground Surface
5" Dia Drill Hole
4"ø Std Bk Steel Pipe w/ 4"ø Std Bk Steel Couplings
El 6368 (same as top of embankment)
20°
2"ø Std Bk Steel Pipe w/ 2"ø Std Bk Steel Couplings
Zones 1, 2, 3, 4
3" Dia Drill Hole
Bottom of Upper Mudstone
Zones 5 & 6
1⅝" Dia Drill Hole
Bottom of Hole EL 6040
GROUT HOLE DETAIL
Sta 0+00S to 5+00S
No Scale
Existing ground surface
Grout holes
Sta 19+78 A
Sta 19+68 A
Vertical Hole
5" Dia Drill Hole
4"ø Std Bk Steel Pipe w/ 4"ø Std Bk Steel Couplings
3" Dia Drill Hole
2"ø Std Bk Steel Pipe w/ 2"ø Std Bk Steel Couplings
Beginning With The First Hole After Sta 19+68 A Each Hole Shall Be Inclined 2½° More Than The Preceding Hole Until a Full 20° From The Vertical is Attained. These Holes Shall Be Located As Close Together As Practical Between 19+68 A And 19+78 A.
DETAIL 'A'
No Scale
1⅝" Dia Drill Hole
5+00S End Grout Curtain
Existing Ground Surface
Overburden
Primary Grout Holes 10 cc Typ
See Detail A This Plate
State Hwy 96 Top of Embankment
Primary Grout Holes 20 cc Typ
EL 6368
EL 6318
EL 6268
Sandstone
Embankment
Upper Mudstone
Sand
EL 6040
NOTE: Refer to Grout Log for Depth of Holes
Zone 6 Deleted From 2+50S To 5+00S
6500
6400
6300
6200
6100
6000
6+00S
5+00S
4+00S
3+00S
2+00S
1+00S
0+00
SUPPLEMENTAL GROUTING


State Hwy 96, Top of Embankment El 6368
Protective Cap (see specs)
Upon Completion of Grouting, Grout Pipe Shall Be Cut Off At Least 6" Below Existing Road Surface (see specs)
Embankment Fill
Approx Final Foundation Excavation in Bedrock
5" Dia Drill Hole
4" ø Std Blk Steel Pipe w/ 4" ø Std Blk Steel Couplings
3" Dia Drill Hole
2" ø Std Blk Steel Pipe w/ 2" ø Std Blk Steel Couplings
Bottom of Upper Mudstone
1⅞" Dia Drill Hole
Bottom of Hole El 6000
GROUT HOLE DETAIL
Sta 18+60A to 19+80A
No Scale
3" Dia Drill Hole
2" ø Std Blk Steel Pipe w/ 2" ø Std Blk Steel Couplings
10' If Sandstone, To Bottom of Mudstone If Mudstone
GROUT HOLE DETAIL
Sta 14+80A to 18+60A
No Scale
Grout Holes
Sta 19+78 A± 20° Inclined Hole
Sta 19+68 A± Vertical Hole
Existing ground surface
Bottom of Upper Mudstone
Zones 5 & 6
Beginning With The First Hole After Sta 19+68 A± Each Hole Shall Be Inclined 2½° More Than The Preceding Hole Until a Full 20° From The Vertical Is Attained. These Holes Shall Be Located As Close Together As Practical Between 19+68 A± And 19+78 A±
DETAIL 'A'
No Scale
OLE DETAIL
to 5+00S
Grout Holes, See Details This Plate
Dam Axis
State Hwy 96, Top of Embankment
Upstream
Downstream
TYPICAL GROUT HOLE LOCATION ALONG DAM CREST
No Scale
Primary Grout Holes, 10 cc, Typ @ 20° Off Vert
See Detail A This Plate
State Hwy 96, Top of Embankment (El 6368)
Primary Grout Holes, 20 cc, Typ
Begin Grout Curtain
Embankment Fill
Approx Exist Foundation Excavation in Bedrock
Sandstone
Upper Mudstone
Sand
NOTE: Refer to Grout Log for Depth of Holes
Zone 6 Deleted From 2+50S To 5+00S
3+00S
2+00S
1+00S
0+00S
SUPPLEMENTAL GROUTING
LEGEND
ASSUMED LITHOLOGIC CONTACT
LIMITS OF GROUTING
ZONE BOUNDARIES
ABIQUIU DAM
SUPPLEMENTAL GROUTING & DRAINAGE SYSTEM
GROUTING DETAILS & CROSS-SECTION
RGAB-AN-2
8

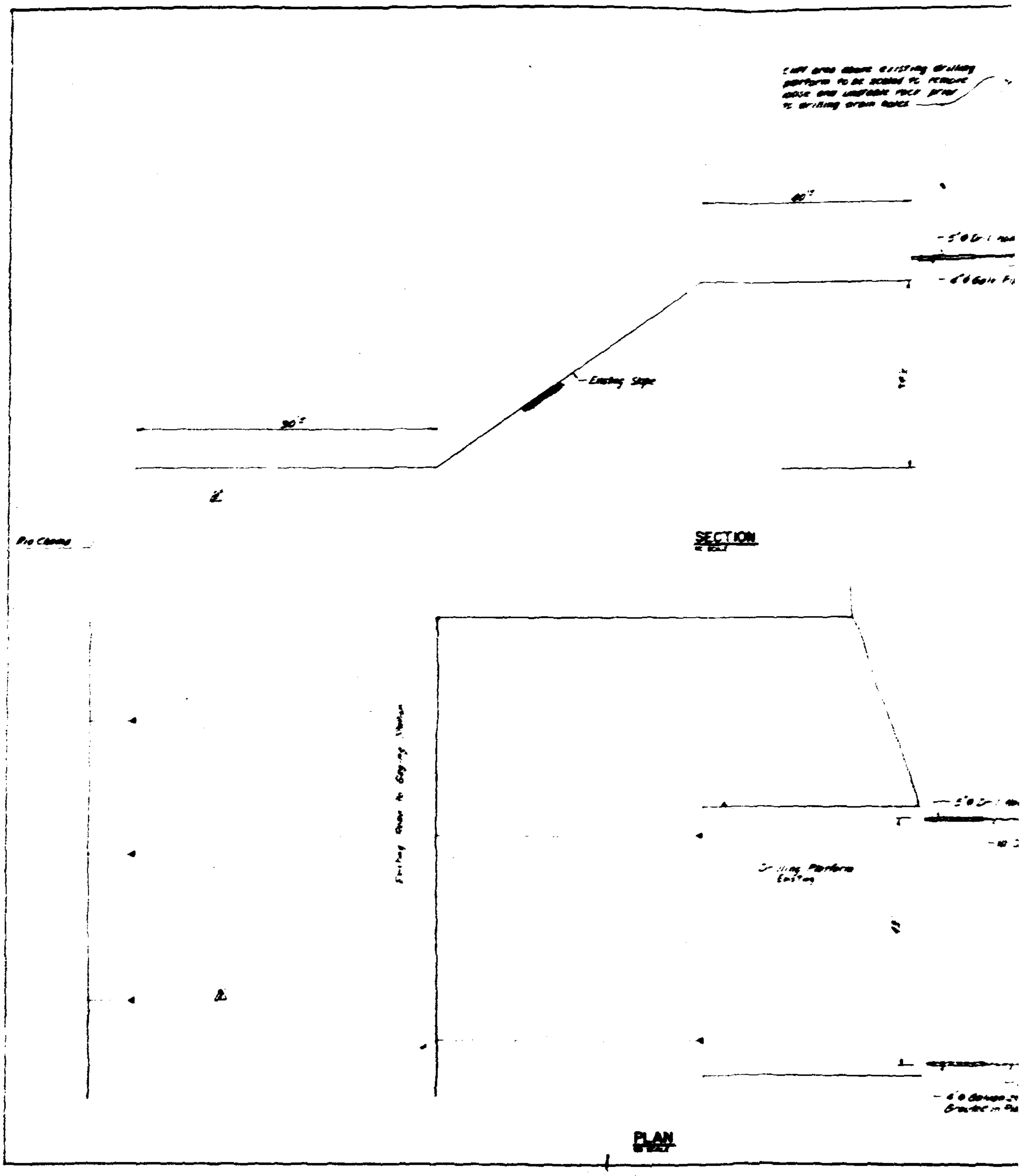


SUPPLEMENTAL GROUTING

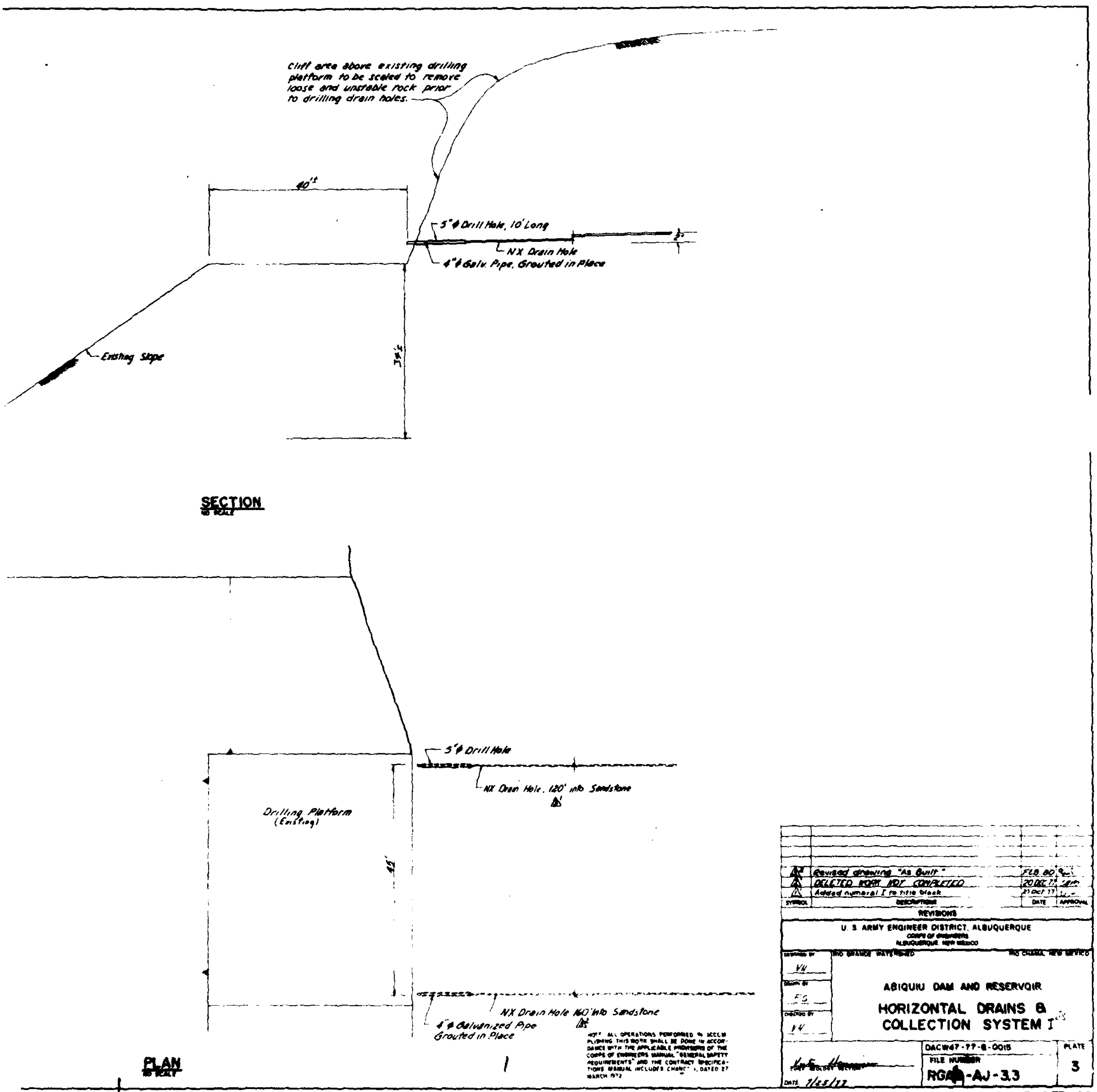
VALUE ENGINE



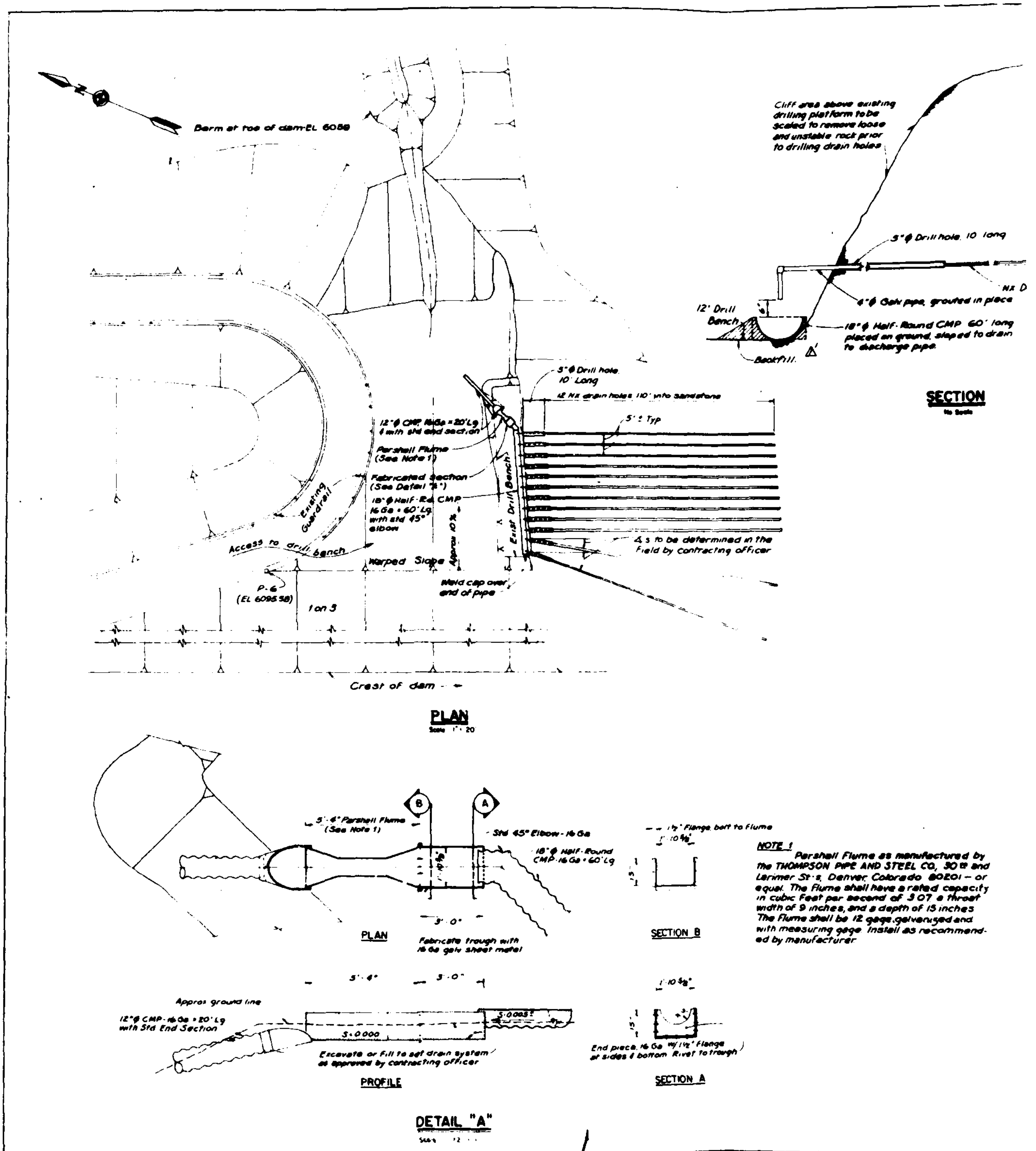
EMBANKMENT CRITERIA AND PERFORMANCE REPORT PLATE 45



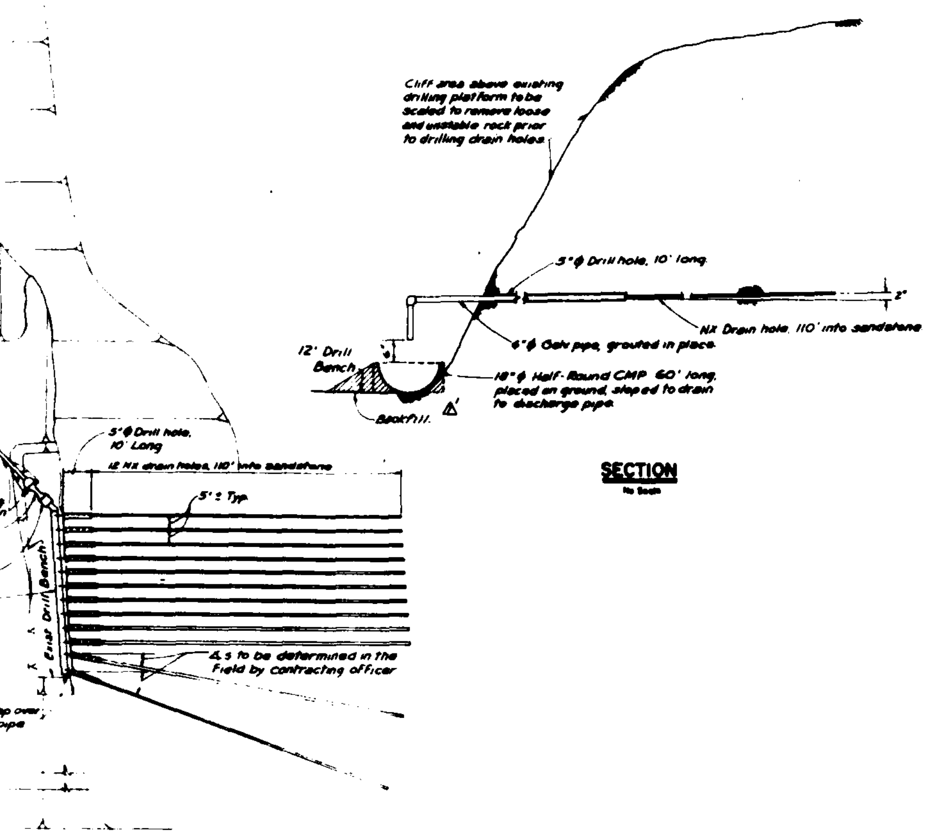
VALUE ENGINEERING PROPOSALS

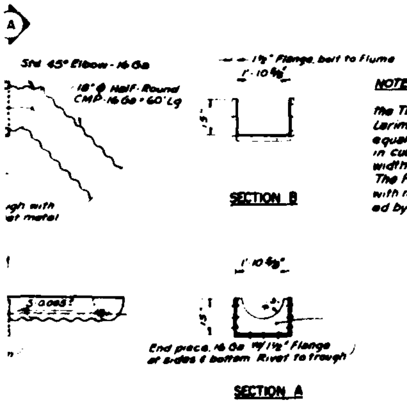


VALUE ENGINEERING PROPOSALS MEAN HIGHER PROFITS



VALUE ENGINEERING PROPOSALS MEAN HI





NOTE 1

Parshall Flume as manufactured by the THOMPSON PIPE AND STEEL CO, 30th and Larimer St's, Denver, Colorado 80201 – or equal. The Flume shall have a rated capacity in cubic Feet per second of 3.07, a throat width of 9 inches, and a depth of 15 inches. The Flume shall be 12 gage, galvanized and with measuring gage. Install as recommended by manufacturer.

NOTE: ALL OPERATIONS PERFORMED IN ACCOMPLISHING THIS WORK SHALL BE DONE IN ACCORDANCE WITH THE APPLICABLE PROVISIONS OF THE CORPS OF ENGINEERS PUBLICATION "GENERAL SAFETY REQUIREMENTS MANUAL", DATED 1 JUNE 1977 AND THE CONTRACT SPECIFICATIONS.

SYMBOL	DESCRIPTIONS	DATE	APPROVAL
1	Revised drawing "As Built" Added this plate	FEB 80	

REVISIONS

U S ARMY ENGINEER DISTRICT ALBUQUERQUE
CORPS OF ENGINEERS
ALBUQUERQUE NEW MEXICO

RIO GRANDE WATERSHED — RIO CHAMA NEW MEXICO

DESIGNED BY: VH & GWB
DRAWN BY: JLS
CHECKED BY: VH

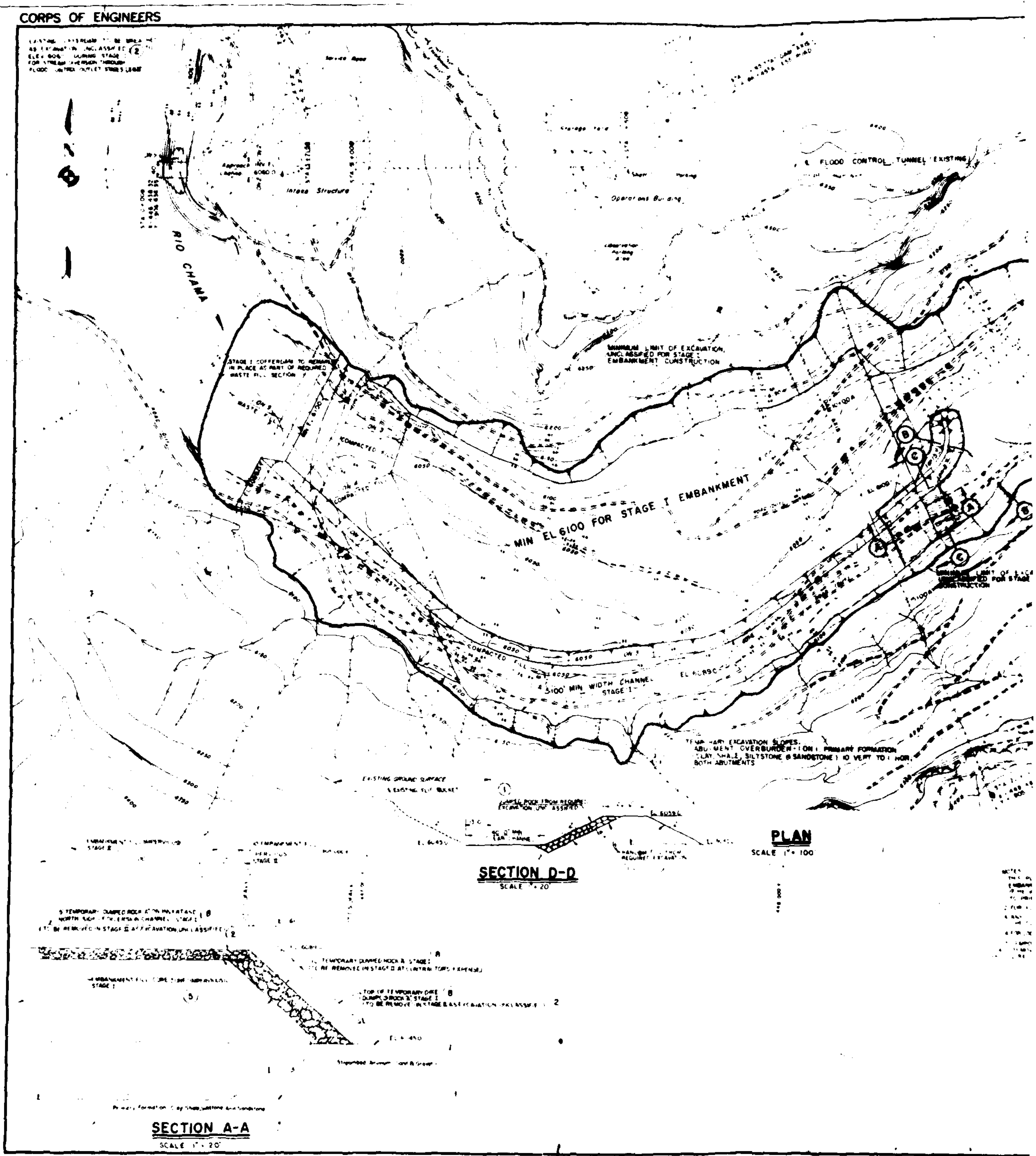
ABIQUIU DAM AND RESERVOIR

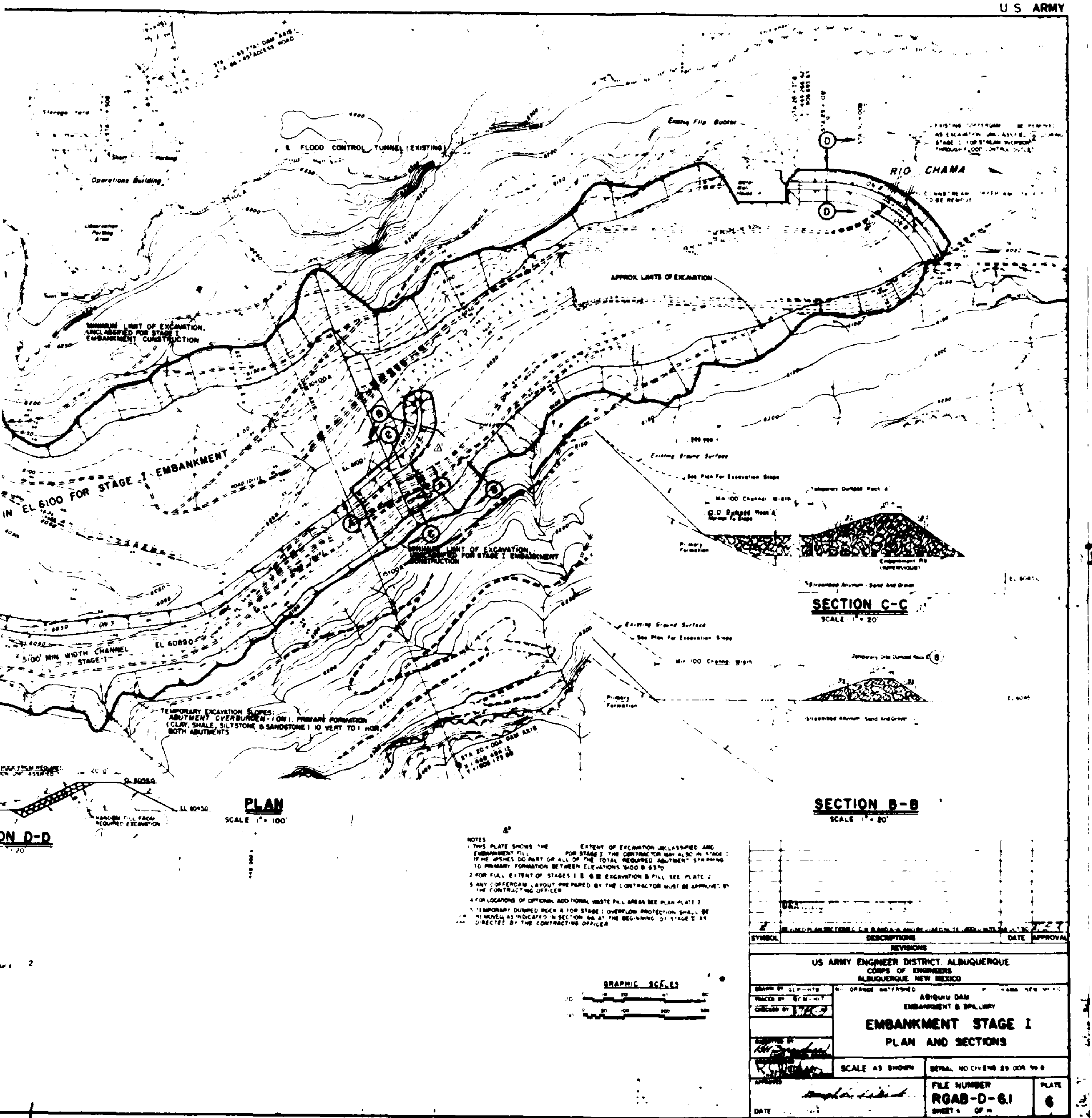
COLLECTION SYSTEM II

CHIEF GEOLOGY SECTION
DATE 22 NOV 77

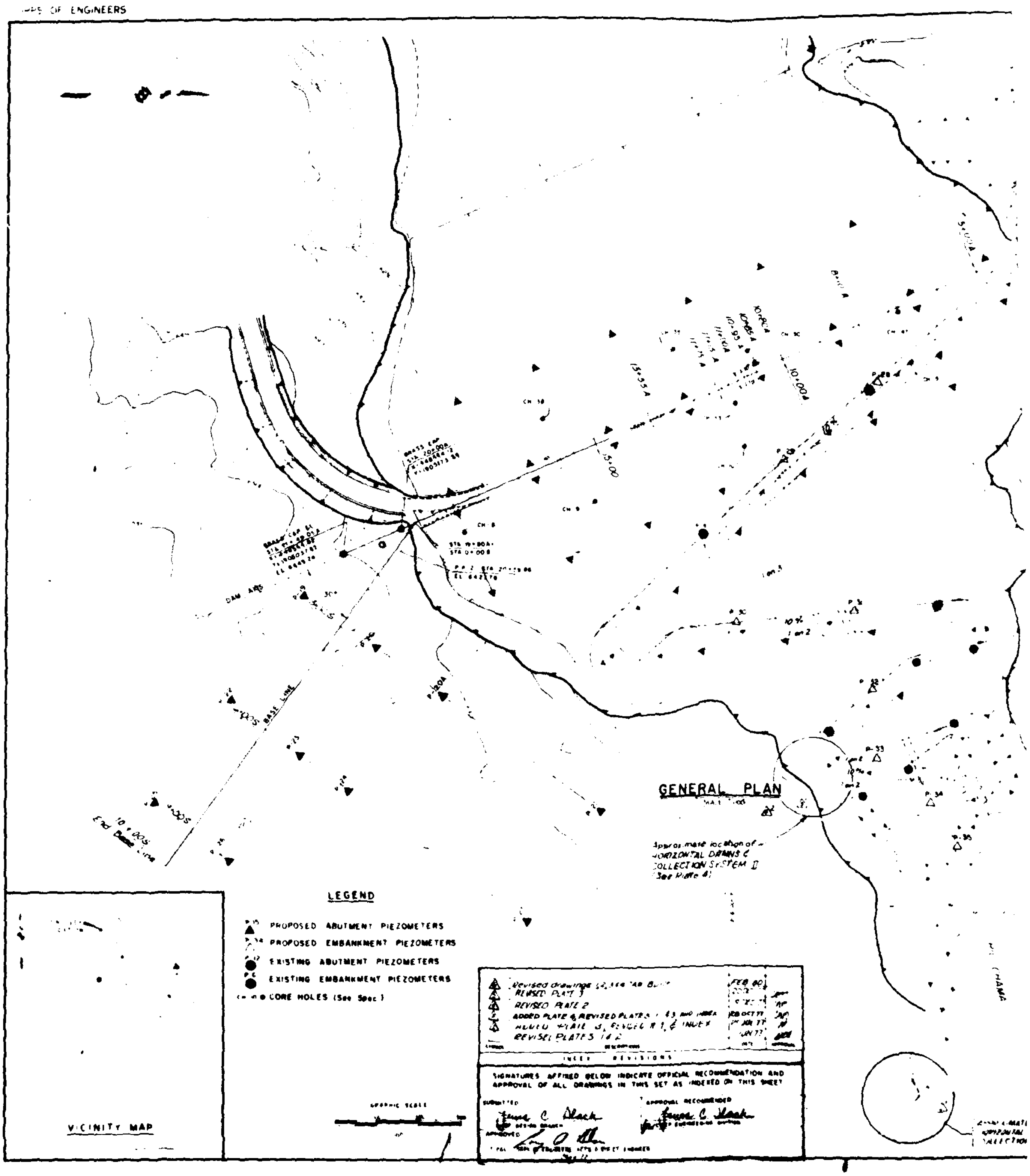
DACW47-77-B-0015
FILE NUMBER
RGAB-AJ-4.1
PLATE 4

VALUE ENGINEERING PROPOSALS MEAN HIGHER PROFITS


CORPS OF ENGINEERS
RIO CHAMA
Intake Structure
Operations Building
FLOOD CONTROL TUNNEL (EXISTING)
MINIMUM LIMIT OF EXCAVATION, UNCLASSIFIED FOR STAGE I EMBANKMENT CONSTRUCTION
STAGE I COFFERDAM TO REMAIN IN PLACE AS PART OF REQUIRED WASTE FILL SECTION
WASTE FILL
COMPACTED FILL
MIN EL 6100 FOR STAGE I EMBANKMENT
6100 MIN WIDTH CHANNEL STAGE I
TEMPORARY EXCAVATION SLOPES, ABUTMENT OVERBURDEN 1 ON 1, PRIMARY FORMATION CLAY SHALE, SILTSTONE & SANDSTONE 1 (0 VERT TO 1 HOR) BOTH ABUTMENTS
EXISTING GROUND SURFACE
PLAN
SCALE 1" = 100'
SECTION D-D
SCALE 1" = 20'
TEMPORARY DUMPED ROCK & STAGE I
TO BE REMOVED IN STAGE II AT CONTRACTOR'S EXPENSE
TOP OF TEMPORARY DIKE
DUMPED ROCK & STAGE I
SECTION A-A
SCALE 1" = 20'



U S ARMY
FLOOD CONTROL TUNNEL (EXISTING)
Operations Building
RIO CHAMA
APPROX. LIMITS OF EXCAVATION
MINIMUM LIMIT OF EXCAVATION, UNCLASSIFIED FOR STAGE I EMBANKMENT CONSTRUCTION
MIN EL 6100 FOR STAGE I EMBANKMENT
5100' MIN WIDTH CHANNEL STAGE I
EL 6089.0
TEMPORARY EXCAVATION SLOPES: ABUTMENT OVERBURDEN - 1 ON 1, PRIMARY FORMATION (CLAY, SHALE, SILTSTONE & SANDSTONE) 10 VERT TO 1 HOR, BOTH ABUTMENTS
PLAN
SCALE 1" = 100'
SECTION C-C
SCALE 1" = 20'
SECTION B-B
SCALE 1" = 20'
Existing Ground Surface
Primary Formation
NOTES
1 THIS PLATE SHOWS THE EXTENT OF EXCAVATION UNCLASSIFIED AND EMBANKMENT FILL FOR STAGE I. THE CONTRACTOR MAY ALSO IN STAGE I IF HE WISHES DO PART OR ALL OF THE TOTAL REQUIRED ABUTMENT STRIPPING TO PRIMARY FORMATION BETWEEN ELEVATIONS 6100 & 6370
2 FOR FULL EXTENT OF STAGES I & II EXCAVATION & FILL SEE PLATE 2
3 ANY COFFERDAM LAYOUT PREPARED BY THE CONTRACTOR MUST BE APPROVED BY THE CONTRACTING OFFICER
4 FOR LOCATIONS OF OPTIONAL ADDITIONAL WASTE FILL AREAS SEE PLAN PLATE 2
5 TEMPORARY DUMPED ROCK B FOR STAGE I OVERFLOW PROTECTION SHALL BE REMOVED AS INDICATED IN SECTION AA AT THE BEGINNING OF STAGE II AS DIRECTED BY THE CONTRACTING OFFICER
GRAPHIC SCALES
SYMBOL
DESCRIPTIONS
DATE
APPROVAL
REVISIONS
US ARMY ENGINEER DISTRICT ALBUQUERQUE
CORPS OF ENGINEERS
ALBUQUERQUE NEW MEXICO
ABIQUIU DAM
EMBANKMENT & SPILLWAY
EMBANKMENT STAGE I
PLAN AND SECTIONS
SCALE AS SHOWN
FILE NUMBER
RGAB-D-6.1
PLATE
6
DATE


ENGINEERS
GENERAL PLAN
LEGEND
PROPOSED ABUTMENT PIEZOMETERS
PROPOSED EMBANKMENT PIEZOMETERS
EXISTING ABUTMENT PIEZOMETERS
EXISTING EMBANKMENT PIEZOMETERS
CORE HOLES (See Spec.)
VICINITY MAP
DAM AXIS
BASE LINE
REVISED PLATE 2
REVISED PLATES 1 & 2
SIGNATURES AFFIXED BELOW INDICATE OFFICIAL RECOMMENDATION AND APPROVAL OF ALL DRAWINGS IN THIS SET AS INDEXED ON THIS SHEET
SUBMITTED
APPROVAL RECOMMENDED
APPROVED

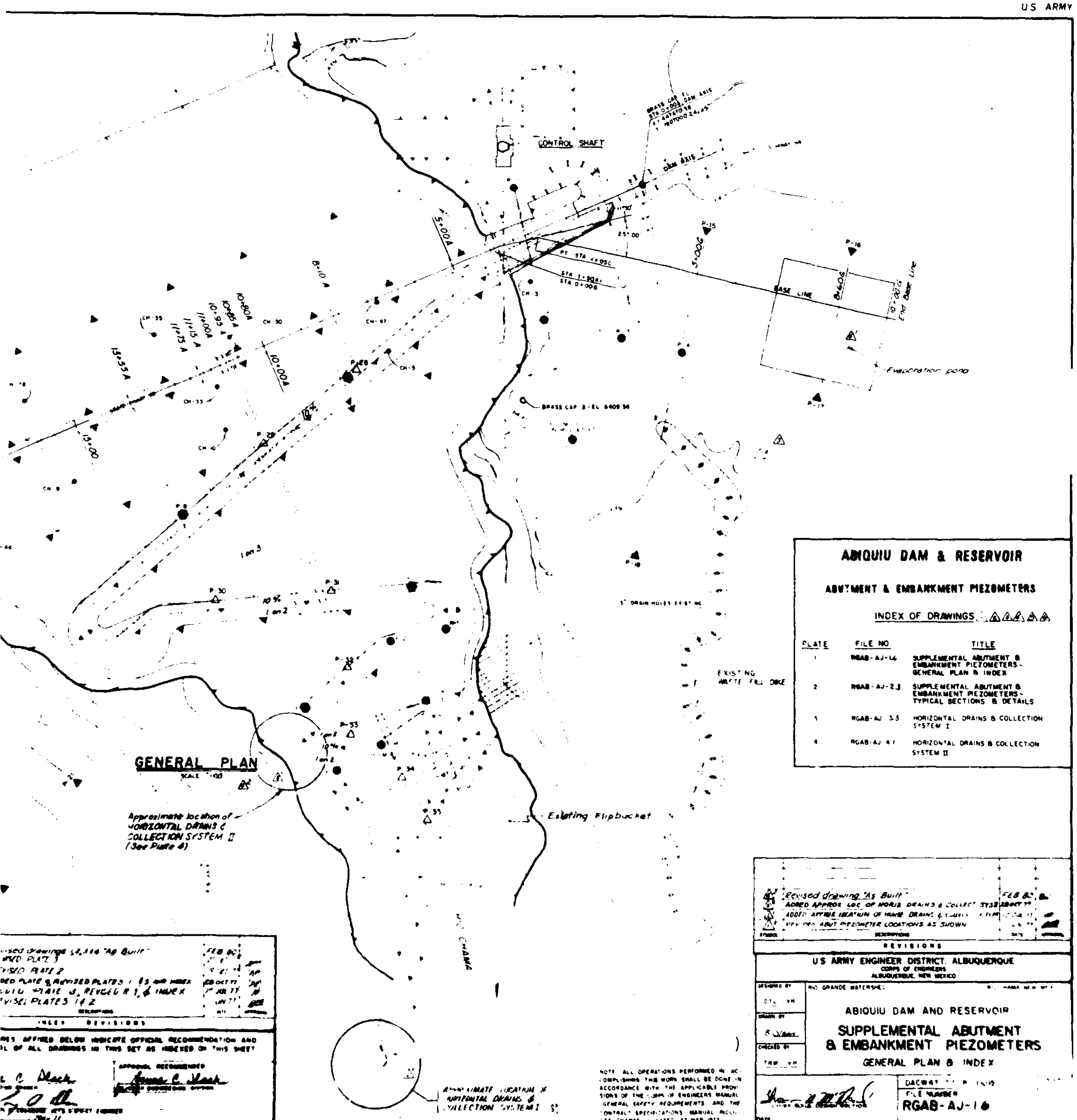
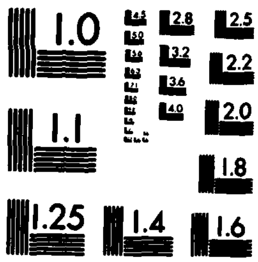


PLATE	FILE NO	TITLE
1	RGAB-AJ-1	SUPPLEMENTAL ABUTMENT & EMBANKMENT PIEZOMETERS - GENERAL PLAN & INDEX
2	RGAB-AJ-2	SUPPLEMENTAL ABUTMENT & EMBANKMENT PIEZOMETERS - TYPICAL SECTIONS & DETAILS
3	RGAB-AJ-3	HORIZONTAL DRAINS & COLLECTION SYSTEM I
4	RGAB-AJ-4	HORIZONTAL DRAINS & COLLECTION SYSTEM II

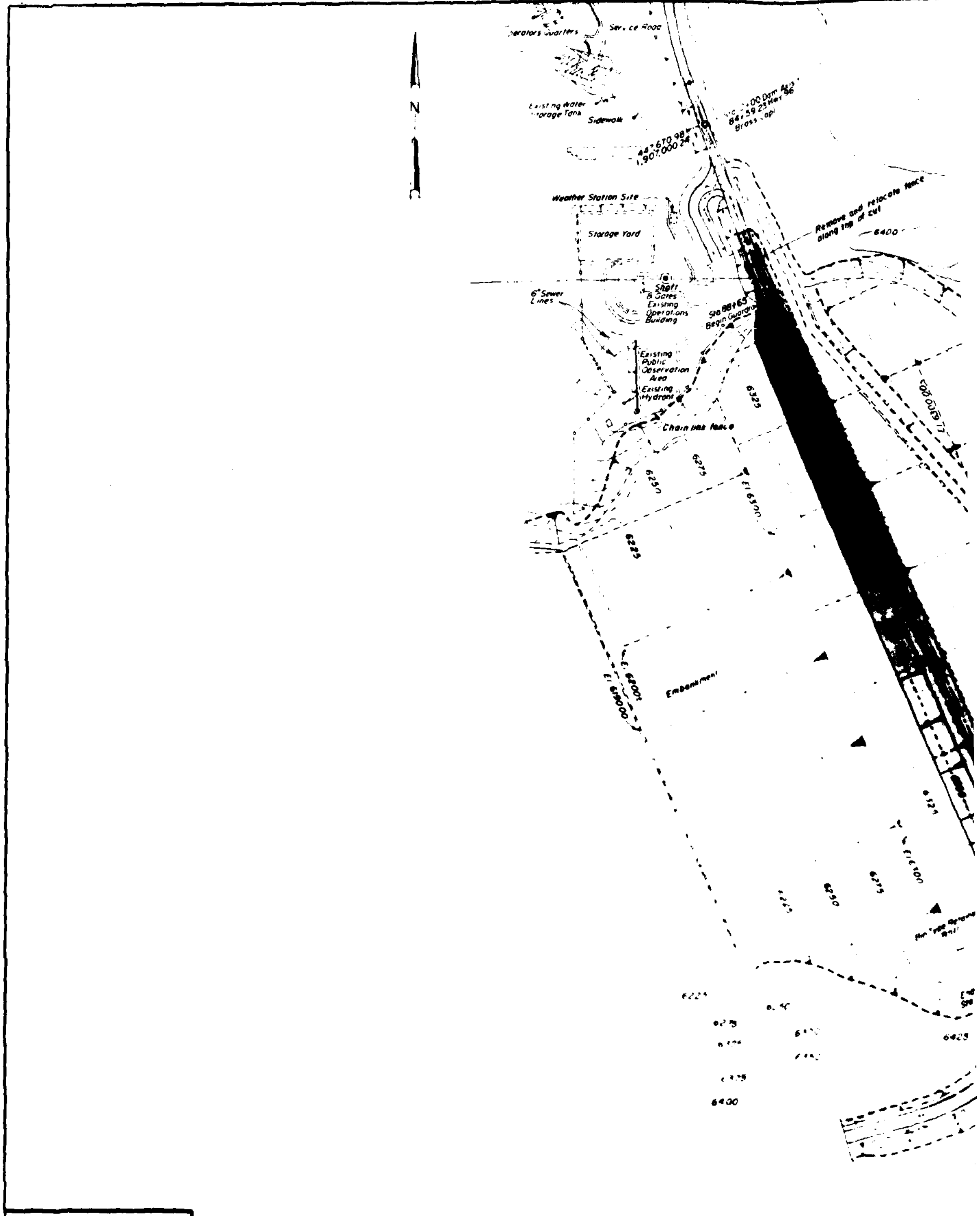
AD-A187 342 ABIQUIU DAM AND RESERVOIR RIO GRANDE BASIN RIO CHAMA NEW MEXICO EMBANKMENT CRITERIA AND PERFORMANCE REPORT (U) CORPS OF ENGINEERS TULSA OK TULSA DISTRICT APR 87 3/3

UNCLASSIFIED F/G 13/2 NL

END
DATE
FILMED
8-

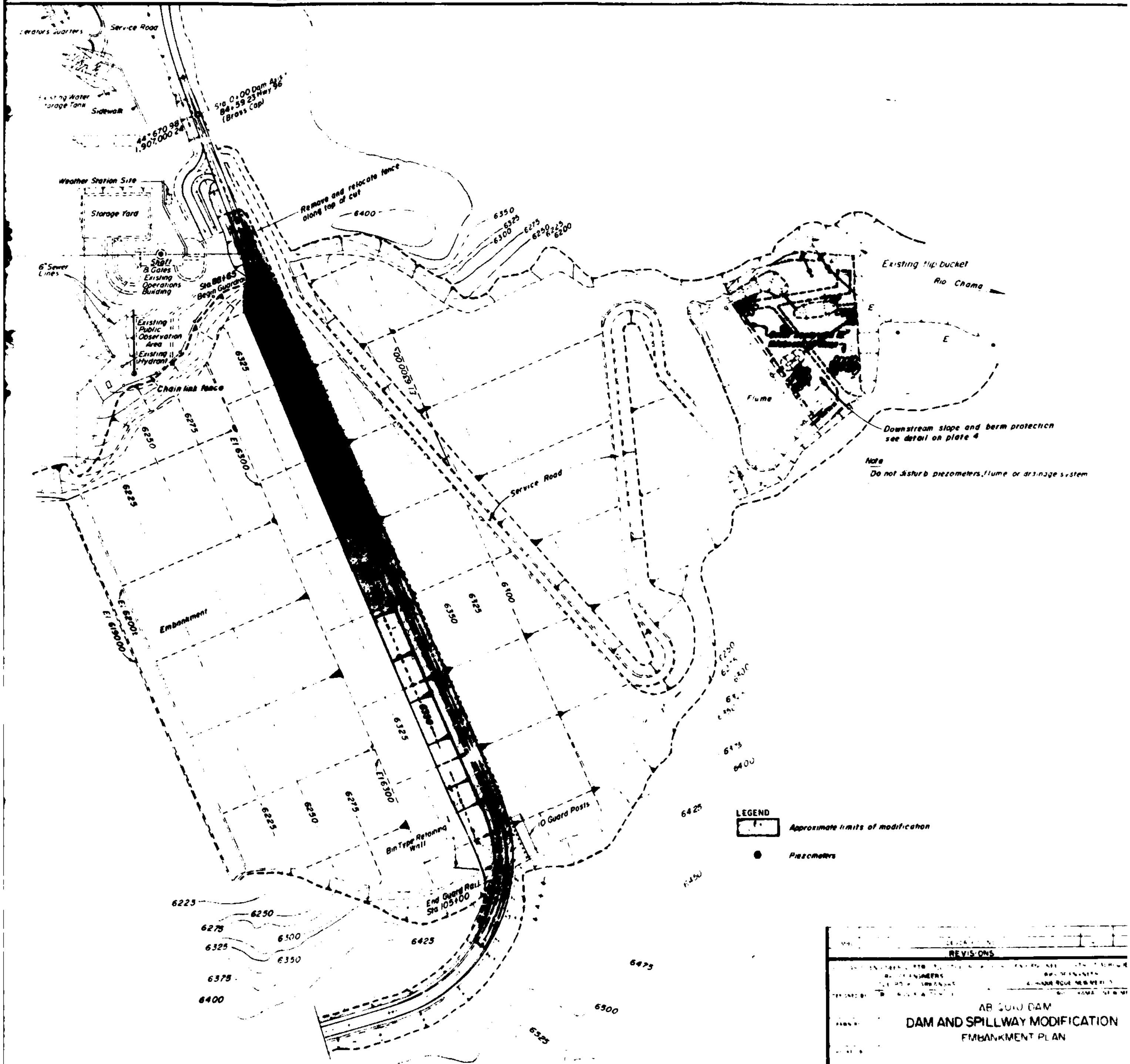


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A


N
Service Road
Existing Water Storage Tank
Sidewalk
Weather Station Site
Storage Yard
Remove and relocate fence along top of cut
6400
Shaft & Gates
Existing Operations Building
6" Sewer Lines
Existing Public Observation Area
Existing Hydrant
Chain link fence
6325
6275
6250
6225
Embankment
6250
6275
6400

WORK SAFELY

VALUE ENGINEERING WILL INCREASE YOUR PROFIT



EMBANKMENT PLAN

REVISIONS

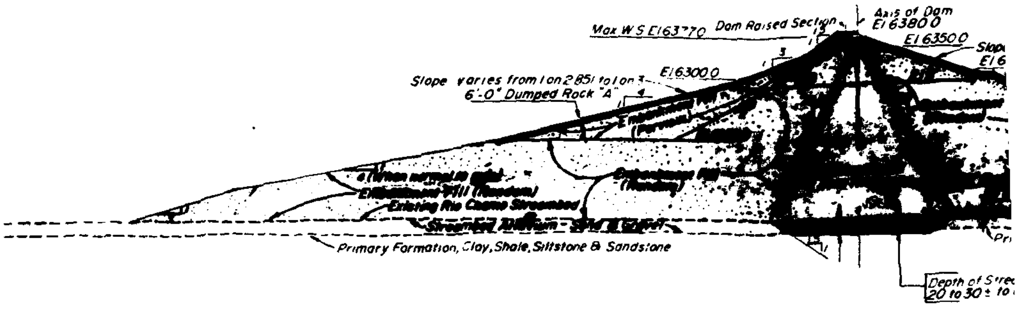
ABIQUIU DAM

DAM AND SPILLWAY MODIFICATION

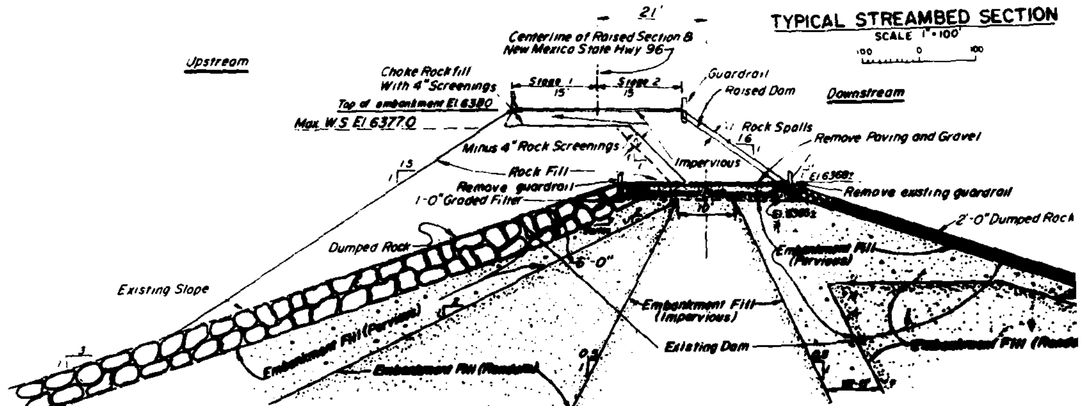
EMBANKMENT PLAN

FILE NUMBER

RGAB-CH-DM-18

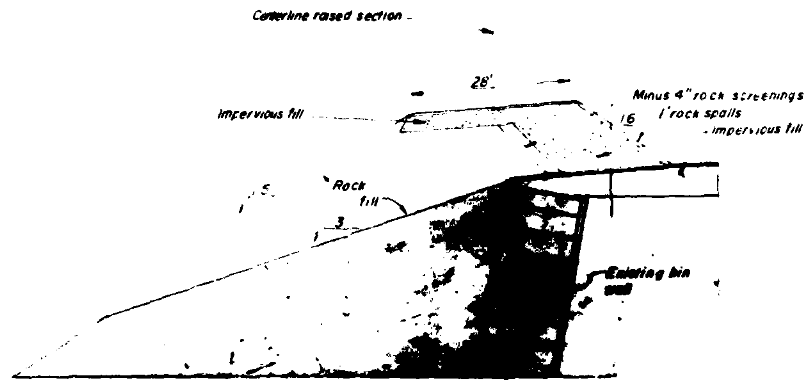


TYPICAL STREAMBED SECTION
SCALE 1"=100'



EMBANKMENT MODIFICATION
TYPICAL SECTION
SCALE 1"=10'

LEGEND
Existing ea



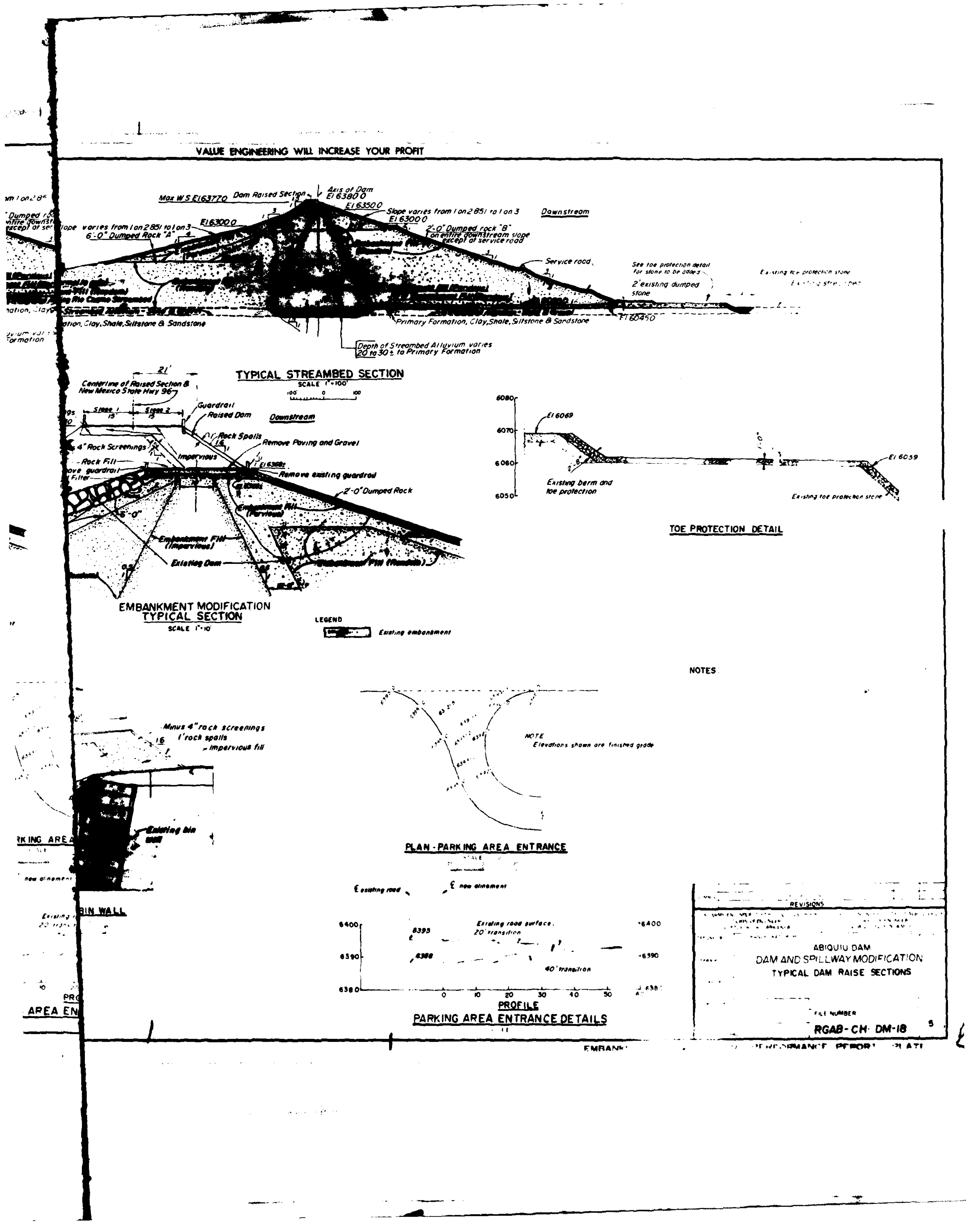
SECTION AT BIN WALL

PL

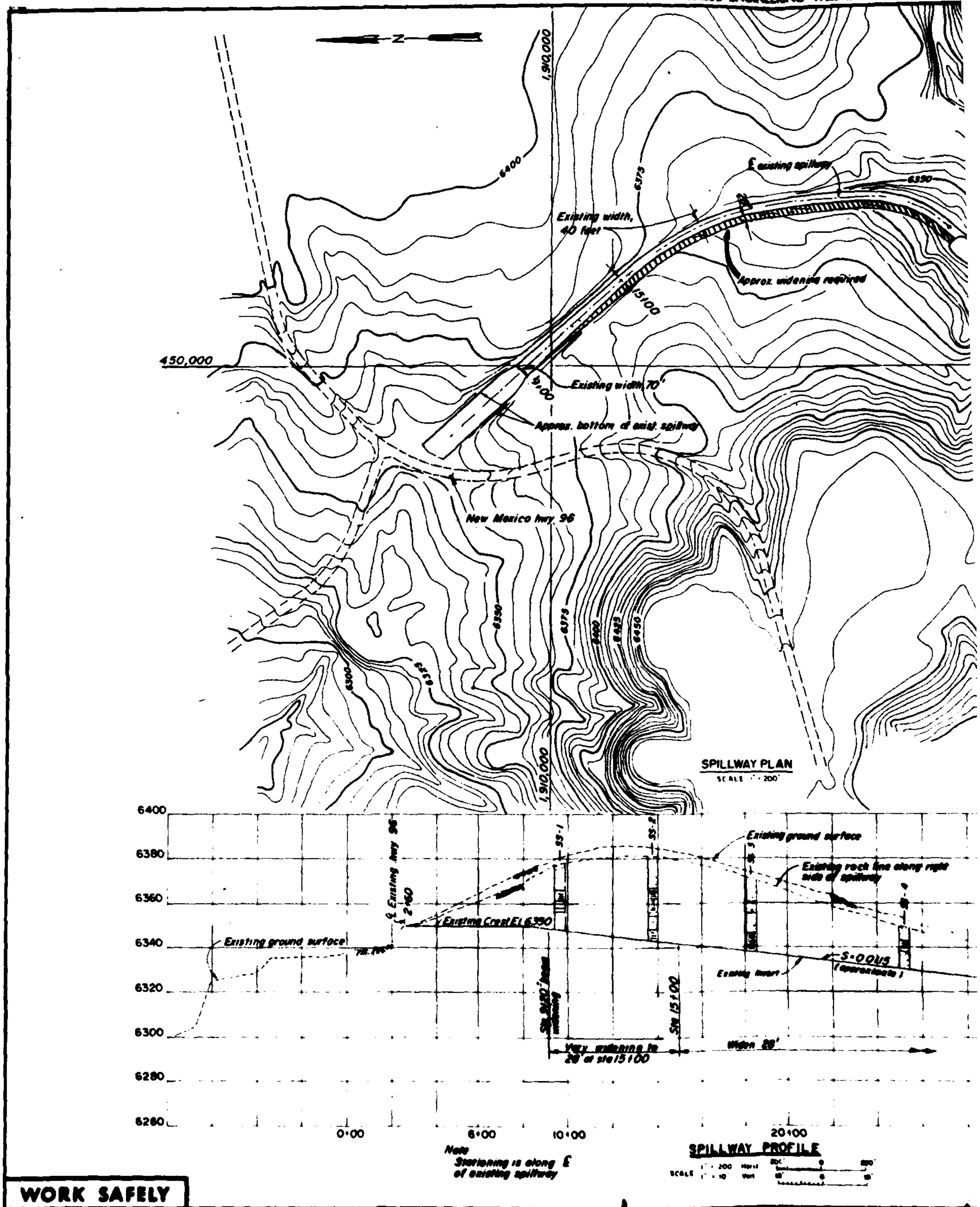
€ existing road

6400
6390
6380

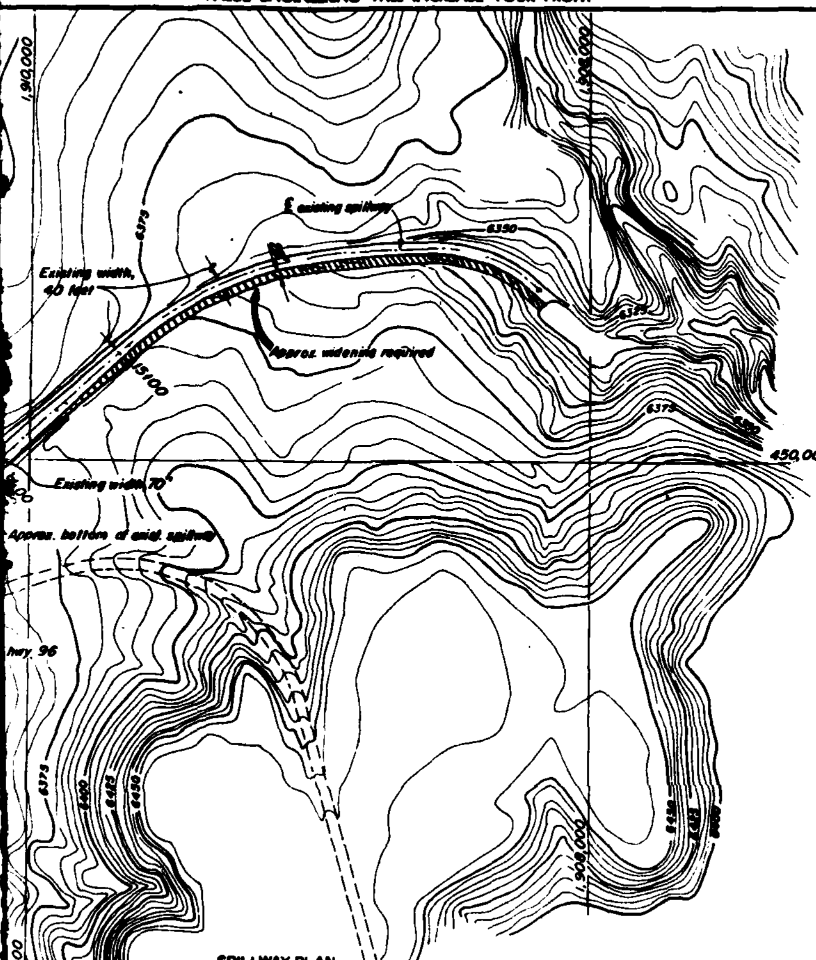
WORK SAFELY


VALUE ENGINEERING WILL INCREASE YOUR PROFIT
Max W S El 6377.0
Dam Raised Section
Axis of Dam
El 6380.0
El 6350.0
Slope varies from 1 on 2.851 to 1 on 3
El 6300.0
Downstream
El 6300.0
Slope varies from 1 on 2.851 to 1 on 3
6'-0" Dumped Rock "A"
2'-0" Dumped rock "B" on entire downstream slope except at service road
Service road
See toe protection detail for stone to be added
2' existing dumped stone
Existing toe protection stone
Primary Formation, Clay, Shale, Siltstone & Sandstone
El 6045.0
Depth of Streambed Alluvium varies 20 to 30± to Primary Formation
TYPICAL STREAMBED SECTION
SCALE 1"=100'
Centerline of Raised Section & New Mexico State Hwy 96
21'
Guardrail
Raised Dam
Downstream
1' Rock Spalls
4" Rock Screenings
Rock Fill
Impervious
Remove Paving and Gravel
El 6368±
Remove existing guardrail
2'-0" Dumped Rock
Embankment Fill (Pervious)
6'-0"
Embankment Fill (Impervious)
Existing Dam
Embankment Fill (Random)
EMBANKMENT MODIFICATION
TYPICAL SECTION
SCALE 1"=10'
LEGEND
Existing embankment
El 6069
El 6059
Existing berm and toe protection
Existing toe protection stone
TOE PROTECTION DETAIL
NOTES
Minus 4" rock screenings
1' rock spalls
Impervious fill
Existing bin wall
BIN WALL
NOTE
Elevations shown are finished grade
PLAN - PARKING AREA ENTRANCE
℄ existing road
℄ new alinement
Existing road surface
20' transition
40' transition
6395
6388
PROFILE
PARKING AREA ENTRANCE DETAILS
REVISIONS
ABIQUIU DAM
DAM AND SPILLWAY MODIFICATION
TYPICAL DAM RAISE SECTIONS
FILE NUMBER
RGAB-CH- DM-18
5

VALUE ENGINEERING WILL INCREASE YOUR P

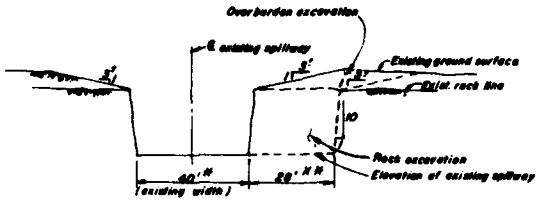


VALUE ENGINEERING WILL INCREASE YOUR PROFIT



SPILLWAY PLAN

SCALE 1" = 200'



TYPICAL SPILLWAY SECTION

SCALE 1" = 20'

\# Varies from 70' to 40' between sta. 9+00 and 15+00

\## Widening varies from 0' to 28' between sta. 9+20' and 15+00

GEOLOGY LEGEND

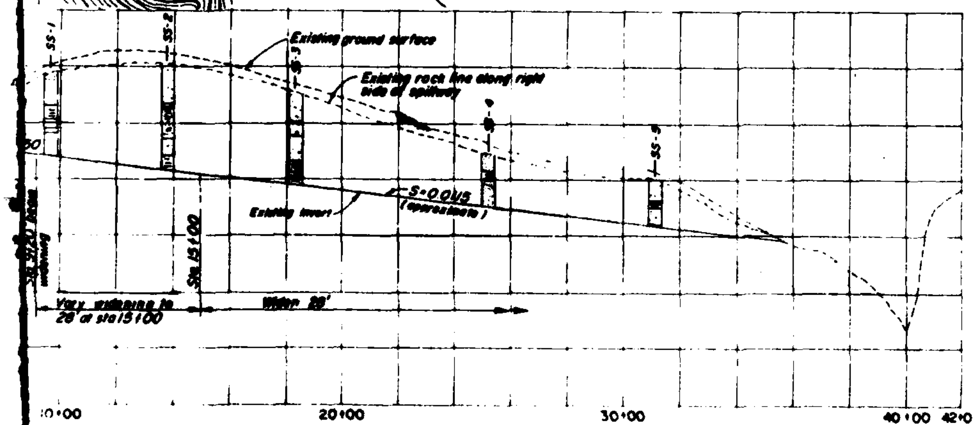
Sand stone

Sand stone with silt stone or mud stone

Conglomerate

Mud stone or silt stone

NOTE:
1. Logs for section are shown in appendix I
2. 10V : 1H slopes are approximate



SPILLWAY PROFILE

SCALE 1" = 200' Horiz. 1" = 10' Vert.

SYMBOL		DESCRIPTIONS	DATE	APPROVAL
REVISIONS				

U.S. ARMY ENGINEER DISTRICT, LITTLE ROCK
CORPS OF ENGINEERS
LITTLE ROCK, ARKANSAS

U.S. ARMY ENGINEER DISTRICT, ALBUQUERQUE
CORPS OF ENGINEERS
ALBUQUERQUE, NEW MEXICO

RIO GRANDE WATERSHED — RIO CHAMA, NEW MEXICO

ABIQUIU DAM
DAM AND SPILLWAY MODIFICATION
SPILLWAY PLAN, PROFILE AND SECTION

DESIGNED BY H.R.
DRAWN BY B.O.
CHECKED BY J.W.
SUBMITTED BY

FILE NUMBER RGAB-CH-DM-18

PLATE 7

DATE MAY 1968

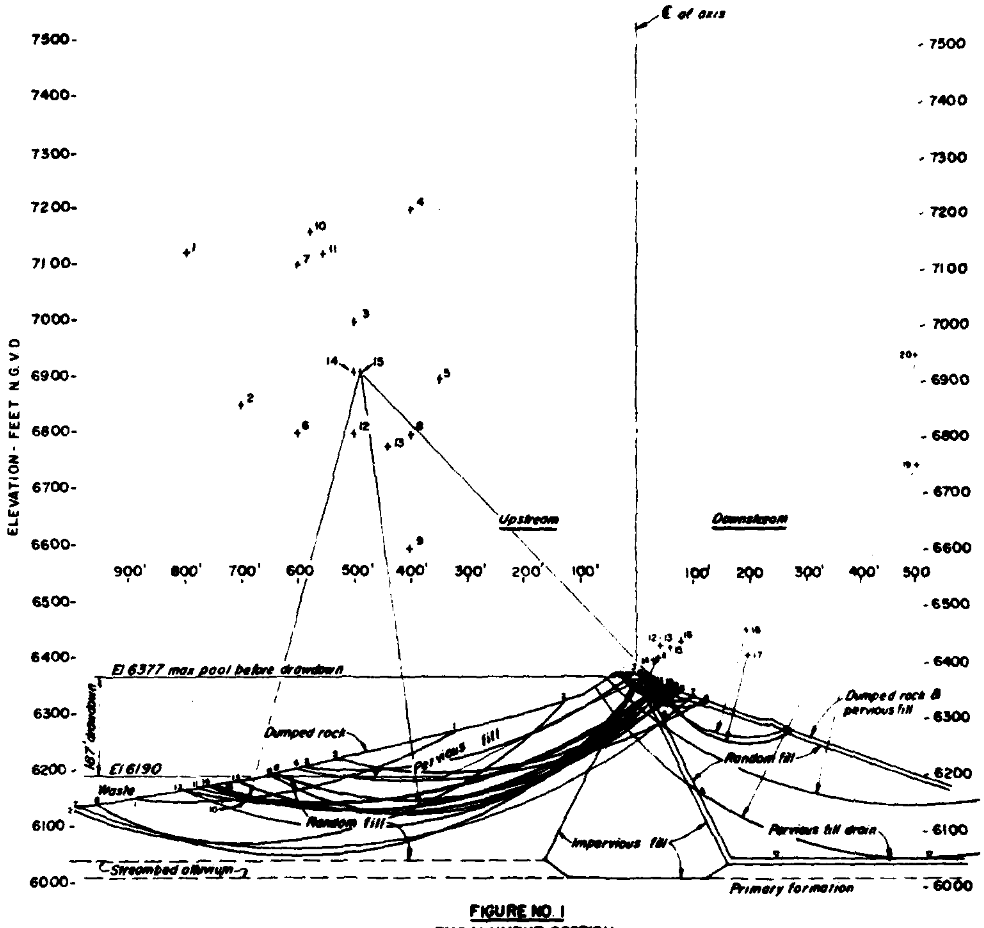


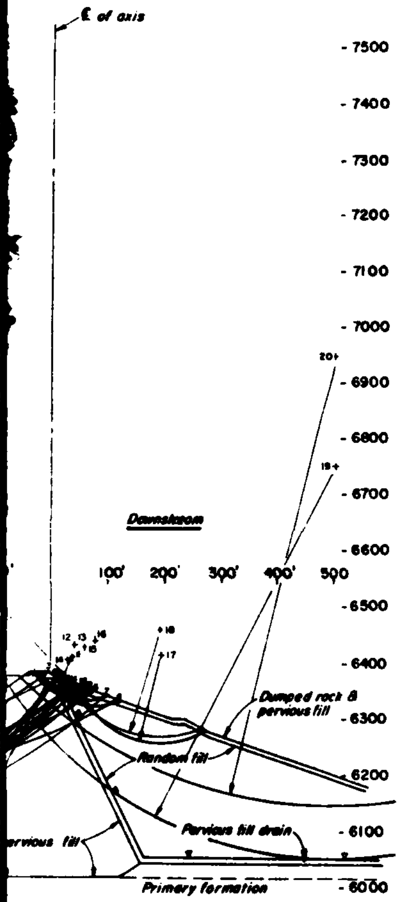
FIGURE NO. I
EMBANKMENT SECTION

LEGEND

Δ Indicates saturation line in embankment

SUMMARY OF COMPUTER ANALYSIS				
ARC NO	X	Y	R	F.S.
1	- 800	7120	980	3.51
2	- 700	6850	780	2.6
3	- 500	7000	800	2.18
4	- 400	7200	1020	2.14
5	- 350	6900	700	2.06
6	- 600	6800	750	2.04
7	- 600	7100	1040	2.01
8	- 400	6800	650	1.81
9	- 400	6600	470	1.80
10	- 580	7160	1020	1.75
11	- 560	7120	980	1.73
12	- 500	6800	700	1.72
13	- 440	6780	650	1.67
14	- 500	6910	780	1.67
15	- 490	6910	780	1.67*

Minimum verified by manual solution, F.S. = 1.65, see plate 11



ON

NOTES:

1. *Refer to plate 11 for manual solution of minimum critical failure arc and soil strengths and properties used in computer analysis.*
2. *Arc numbers listed in "Summary of Computer Analysis" table shown above refer to upstream failure arcs., failure arcs shown in fig. 1 on downstream slope are summarized in table on plate 12, and are for end of construction computer solution.*

SYMBOL		DESCRIPTION	DATE	APPROVAL
REVISIONS				

U.S. ARMY ENGINEER DISTRICT LITTLE ROCK
CORPS OF ENGINEERS
LITTLE ROCK ARKANSAS

U.S. ARMY ENGINEER DISTRICT ALBUQUERQUE
CORPS OF ENGINEERS
ALBUQUERQUE NEW MEXICO

RIO GRANDE WATERSHED — RIO CHAMA, NEW MEXICO

ABIQUIU DAM
DAM AND SPILLWAY MODIFICATION
SLOPE STABILITY ANALYSIS
SUDDEN DRAWDOWN-CASE II
(COMPUTER SOLUTION SUMMARY)

DESIGNED BY: RLA
DRAWN BY: BNB
CHECKED BY: RLA
SUBMITTED BY:
DATE: MAY 1982

FILE NUMBER: RGAB-CH-DM-18

PLATE: 11

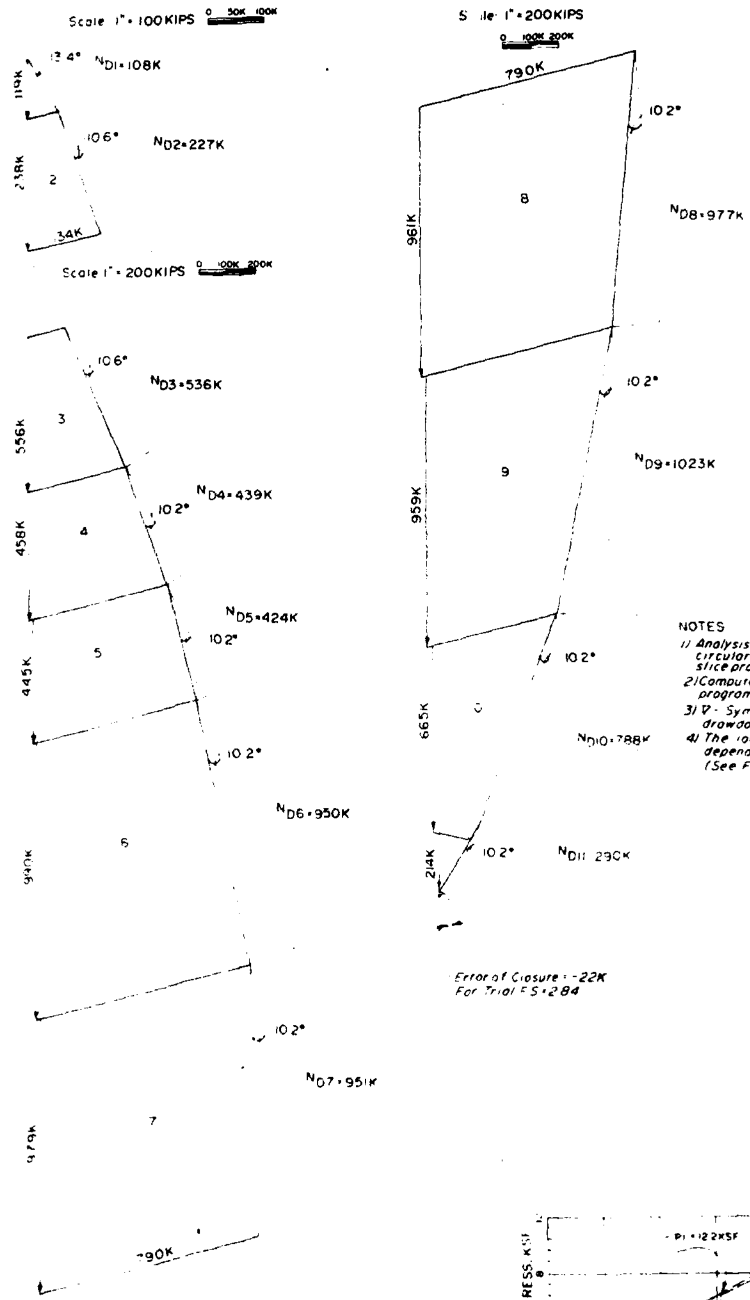


FIGURE NO 2

Composite Force Polygon of before drawdown for trial factor of safety = 2.84 Scale as shown on Figure)

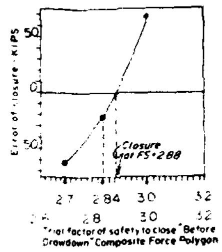


FIGURE NO 5
TRIAL FS VS ERROR OF CLOSURE FOR BEFORE DRAWDOWN POLYGON

NOTES

1) Analysis performed according to EM1110-2-1902, circular arc modified Swedish Method, finite slice procedure

2) Computer solution F.S. = 1.65 by 10009 (WESLIB/KCWEG) program on Southwestern Division System

3) ∇ - Symbols outline Phreatic Surface after drawdown for manual and computer solution

4) The lower of R or S strength used in analysis depending on normal stress on slice base (See Figure 3)

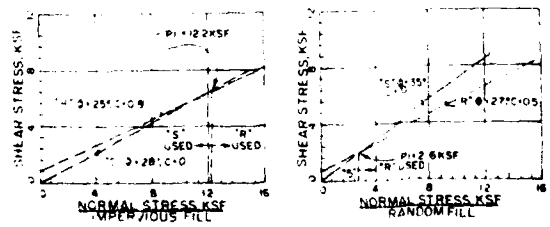


FIGURE NO 3
COMPOSITE STRENGTH ENVELOPES

WORK SAFELY

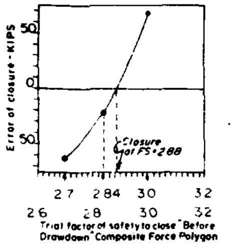


FIGURE NO 5
TRIAL FS VS ERROR OF CLOSURE FOR BEFORE DRAWDOWN POLYGON

AFTER DRAWDOWN FS CALCULATION TABLE										
Material	Slice	N_D Kips	φ°	N_D x Tan φ	ΔL Ft	C KSF	CΔL Kips	θ°	W Kips	W SIN θ Kips
Random (S)	1	108	34°	73	49	0	0	43.3°	119	82
Impervious (S)	2	227	28°	121	57	0	0	37.5°	343	209
	3	536	28°	285	71	0	0	33.3°	911	500
Random (R)	4	439	27°	224	58	0.5	29	29.0°	891	432
	5	424	27°	216	66	0.5	33	24.3°	815	335
	6	950	27°	484	86	0.5	43	21.2°	1639	593
	7	951	27°	485	90	0.5	45	11.8°	1424	291
	8	977	27°	498	95	0.5	48	4.9°	1282	110
	9	1023	27°	521	110	0.5	55	-1.2°	1210	-25
	10	788	27°	402	121	0.5	61	-10.3°	757	-135
	11	290	27°	148	89	0.5	45	-19.6°	214	-72
TOTALS	- Σ			3456			358			2319

$$\text{Manual } FS = \frac{\Sigma N_D \tan\phi + \Sigma C\Delta L}{\Sigma W \sin\theta}$$

$$\text{Manual } FS = \frac{3456 + 358}{2319} = 1.65$$

MEASUREMENTS AND WEIGHTS TABLE										
			Slice Height				Weight in Kips			
Slice	Horizontal Width (Ft)	Base Length of Slice - ΔL (Ft)	Left Side	Right Side	Average (Ft)	Area of Slice in Sq Ft	Submerged	Moist or Saturated	Weight Before Drawdown	Weight After Drawdown
1 1'	34 27	49	12 33	12 0	12 17	408 459	- -	570 620	119	119
2 2' 2"	20 32 38	57	14 0 88	0 48 0	7 24 44	140 768 1672	- - 1130	175 1075 2174	238	343
3 3' 3"	32 60 60	71	8 25 90	8 25 80	8 25 85	256 1500 5100	- 1284 3960	320 210 6685	556	911
4 4	50	58	29 95	29 90	29 93	1450 4650	1241 3608	203 6882	485	891
5 5	44	66	38 92	28 95	33 94	1452 4136	1243 3210	203 6121	445	815
6 6 6'	96	86	55 40 42	40 78 0	48 59 21	4608 5664 2016	3944 4395 1564	645 83-3	990	1639
7 7' 7"	87	90	78 0 57	57 40 42	68 20 50	5916 1740 4350	5064 1350 3376	824 2575	979	1424
8 8	95	95	55 67	68 57	62 62	5890 5890	5042 4571	82' -	961	1282
9 9'	110	110	28 65	56 68	12 66	4620 7260	3955 5633	647	959	1210
10 10	120	121	0 45	28 66	14 56	1680 6720	1438 5215	235 -	665	757
11	120	130	0	45	23	2760	2142	-	214	214

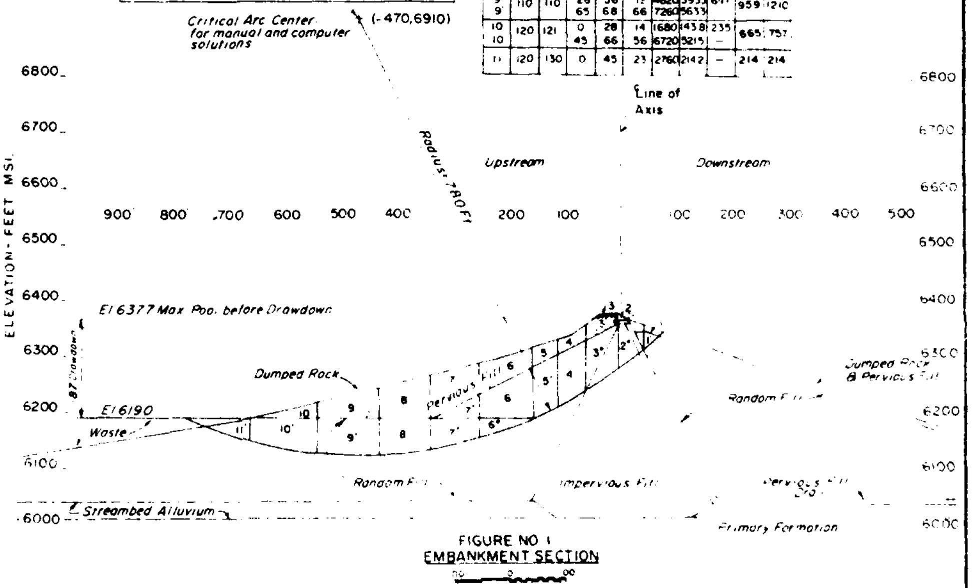


FIGURE NO 1
EMBANKMENT SECTION

NOTES
1) Analysis performed according to EM1110-2-1902, circular arc modified Swedish Method, finite slice procedure
2) Computer solution FS = 1.65 by I0009 (WESLIB/KCWEG) program on Southwestern Division System
3) ∇ - Symbols outline Phreatic Surface after drawdown for manual and computer solution
4) The lower of R or S strength used in analysis depending on normal stress on slice base (See Figure 3)

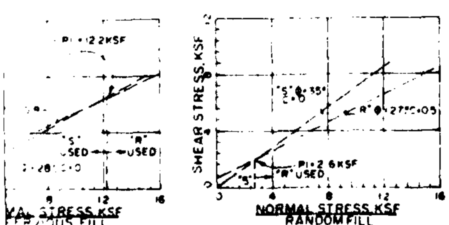


FIGURE NO 3
COMPOSITE STRENGTH ENVELOPES

MATERIAL TYPE	UNIT WEIGHT (LBS/FT³)		R STRENGTHS		S-STRENGTHS	
	γ MOIST	γ SAT	C(KSF)	φ	C(KSF)	φ
Impervious Fill (1)	125.0	130.0	0.8	25°	0	28°
Waste Fill (2)	110.0	115.0	0	20°	0	20°
Rock Fill (3)	140.0	148.0	0	40°	0	40°
Pervious Fill (2)	140.0	148.0	0	35°	0	35°
Random Fill (1)	135.0	140.0	0.5	27°	0	34°
Streambed Alluvium (2)	142.0	148.0	0	35°	0	35°
Primary Formation (2)	132.0	148.0	0	20°	0	20°

Note
(1) Data taken from record sample test.
(2) Data from original design data
(3) Assumed Data

FIGURE NO 4
ADOPTED ANALYSIS DATA
(SUDDEN DRAWDOWN CASE)

REVISIONS

U.S. ARMY ENGINEER DISTRICT, ALBUQUERQUE
RIO GRANDE WATERSHED

ABIQUIU DAM
DAM AND SPILLWAY MODIFICATION
SLOPE STABILITY ANALYSIS
SUDDEN DRAWDOWN - CASE II
(MANUAL SOLUTION)

DESIGNED BY RLA
DRAWN BY BNB
CHECKED BY RLA

DATE MAY 1982
FILE NUMBER
RGAB-CH-DM-18
12

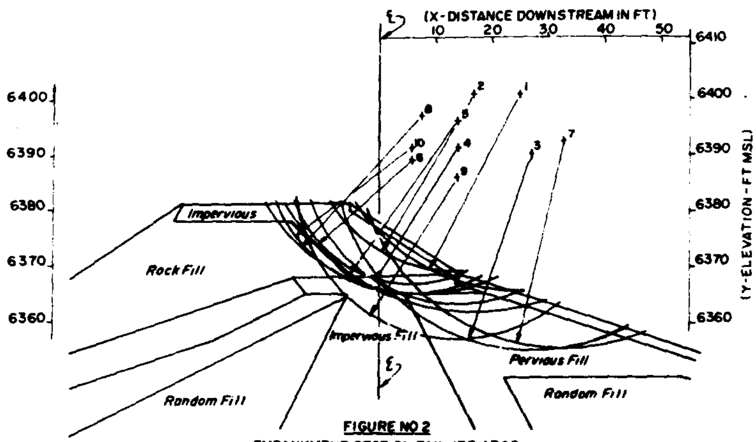


FIGURE NO 2

EMBANKMENT SECTION FAILURE ARCS BY COMPUTER SOLUTION

NOTE:
Additional arcs are shown on Plate 9, Fig. I downstream slope

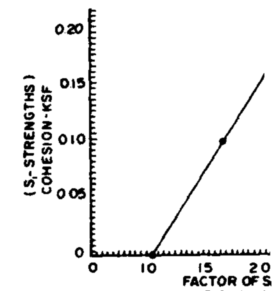


FIGURE N
CRITICAL ARC COMPUTER SOL
VS VARIOUS C(KSF
OF IMPERVIOUS M

DATA USED IN COMPUTER SOLUTION
END OF CONSTRUCTION CASE

MATERIAL TYPE	UNIT WEIGHT (LBS/FT^3)			Q STRENGTHS		S-STRENGTHS		S_r-STRENGTHS	
	MOIST	δ SAT	δ SUB	C(KSF)	ø	C(KSF)	ø	C(KSF)	ø
Impervious Fill	125.0	130.0	68	1.9	8.0	0	28°	0.1	28°
Rock Fill and Dumped Rock	140.0	148.0	86	—	—	0	40°	0	40°
Pervious Fill	140.0	148.0	86	—	—	0	35°	0	35°
Random Fill #	135.0	140.0	78	0.5	27°	0	34°	0	34°

\# *Q strength assumed to be same as R-strength from record sample tests*

COMPUTER SOLUTION SUMMARY OF ARCS

NO	X	Y	R	Q FS	S FS	S1* FS
1	25	6401	35	18.8	0.94	1.92
2	17	6401	39	4.7	2.1	2.2
3	27	6390	35	4.1	2.5	2.7
4	14	6391	28	4.9	2.0	2.1
5	14	6396	27	11.3	1.0	1.68
6	6	6389	22	6.2	2.2	2.3
7	33	6392	37	3.7	2.5	2.6
8	8	6397	32	3.1	2.5	2.5
9	14	6386	29	3.7	3.2	3.2
10	6	6391	26	3.3	2.7	NA
11	35	6414	71	3.0	2.6	NA
12	41	6434	81	2.7	2.1	NA
13	41	6434	91	3.0	2.5	2.3
14	30	6412	61	2.7	2.4	NA
15	54	6431	95	2.8	2.5	NA
16	74	6441	115	2.7	2.4	NA
17	194	6421	155	2.3	2.3	2.2
18	194	6461	195	2.1	2.2	NA
19	500	6750	700	2.3	2.5	2.5
20	800	6950	800	1.9	2.1	2.1

NA - Not analyzed on computer

NOTE: This is not believed a realistic failure arc (very shallow) therefore failure arc NO. 5 selected as critical arc for S_1 strength analysis and is verified by manual solution.
All failure arcs lying entirely in new construction imp. zone will have high F S when Q-strength used in calculations (refer to arcs 1 and 5)

Minimum factor of safety for computer analysis with S_1-strengths used in impervious material

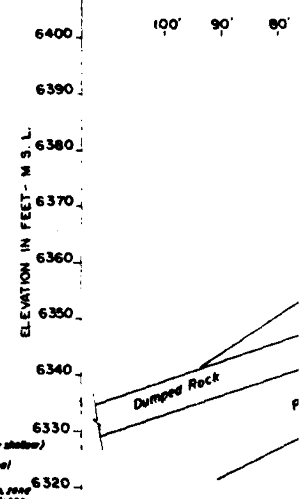
Q FS - *Factor of safety obtained on computer by using record sample Q-test strengths*

S FS *Factor of safety obtained on computer by using record sample S-test strengths.*

S1 FS *Factor of safety obtained on computer by using S_1-test condition strengths selected for verifying embankment stability for end of construction case*

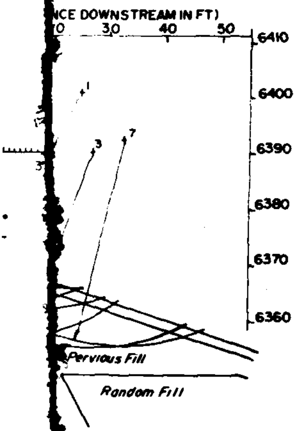
NOTE
Arc numbers 1 thru 10 shown on Fig. 2
Arc numbers 11 thru 20 are shown on plate 9, Fig. 1 downstream slope

* *The designation (S_1) is used to indicate the soil strengths used in the end of construction case analysis. This designation is used to differentiate between the record sample S-test strengths and the S-test strengths selected for use in the analysis*



WORK SAFELY

VALUE ENGINEERING WILL INCREASE YOUR PROFIT



CS

downstream slope

MPUTER SOLUTION
TRUCTION CASE

ENGTHS	S-STRENGTHS		S_1-STRENGTHS	
ø	C(KSF)	ø	C(KSF)	ø
80	0	28°	0.1	28°
—	0	40°	0	40°
—	0	35°	0	35°
27	0	34°	0	34°

ecord sample tests

NOTE: This is not believed a realistic failure arc (very shallow) therefore failure arc NO. 5 selected as critical arc for S_1 strength analysis and is verified by manual solution.
All failure arcs lying entirely in new construction imp. zone will have high F S when Q-strength used in calculations (refer to arcs 1 and 5)

Minimum factor of safety for computer analysis with S_1-strengths used in impervious material

F_S - Factor of safety obtained on computer by using record sample Q-test strengths

F_S - Factor of safety obtained on computer by using record sample S-test strengths.

F_S - Factor of safety obtained on computer by using S_1 test condition strengths selected for verifying embankment stability for end of construction case

NOTE
Arc numbers 1 thru 10 shown on Fig. 2
Arc numbers 11 thru 20 are shown on plate 9, Fig. 1 downstream slope

* The designation (S_1) is used to indicate the soil strengths used in the end of construction case analysis. This designation is used to differentiate between the record sample S-test strengths and the S-test strengths selected for use in the analysis.

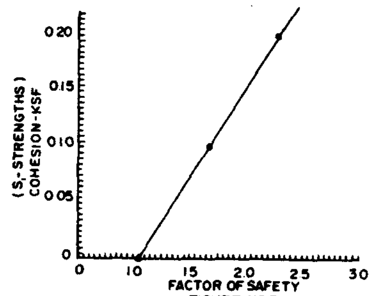


FIGURE NO.3
CRITICAL ARC COMPUTER SOLUTION FS VS VARIOUS C(KSF) W/ ø=28° OF IMPERVIOUS MATERIAL

MANUAL SOLUTION

CALCULATION TABLE

MATERIAL	SLICE	HORIZONTAL WIDTH (FEET)	Slice Height (Feet) LEFT SIDE	RIGHT SIDE	AVERAGE	AREA OF SLICE FT.²	WEIGHT OF SLICE LBS	BASE LENGTH OF SLICE-ΔL FT	CΔL LBS	θ - DEGREES	WT SINθ - LBS	WT COSθ - LBS
IMPERVIOUS	1	3.7'	0	4.6	2.3	8.5	1063	6.0	600	50.7	823	673
	2	6.0	4.6	5.0	4.8	28.8	3600	7.3	730	36.0	2116	2912
	3	5.7	5.0	3.6	4.3	24.5	3063	6.1	610	19.9	1043	2880
	4	7.0	3.6	0	1.8	12.6	1576	7.1	710	8.3	228	1559
Σ								26.5			4210	8024

ARC NO. 5 MANUAL SOLUTION $F.S. = \dfrac{[\Sigma WT(\cos\theta)] \tan\phi + \Delta L C}{\Sigma WT(\sin\theta)}$

MANUAL $F.S. = \dfrac{8024(\tan 28°) + 26.5(100)}{4210} = 1.64$

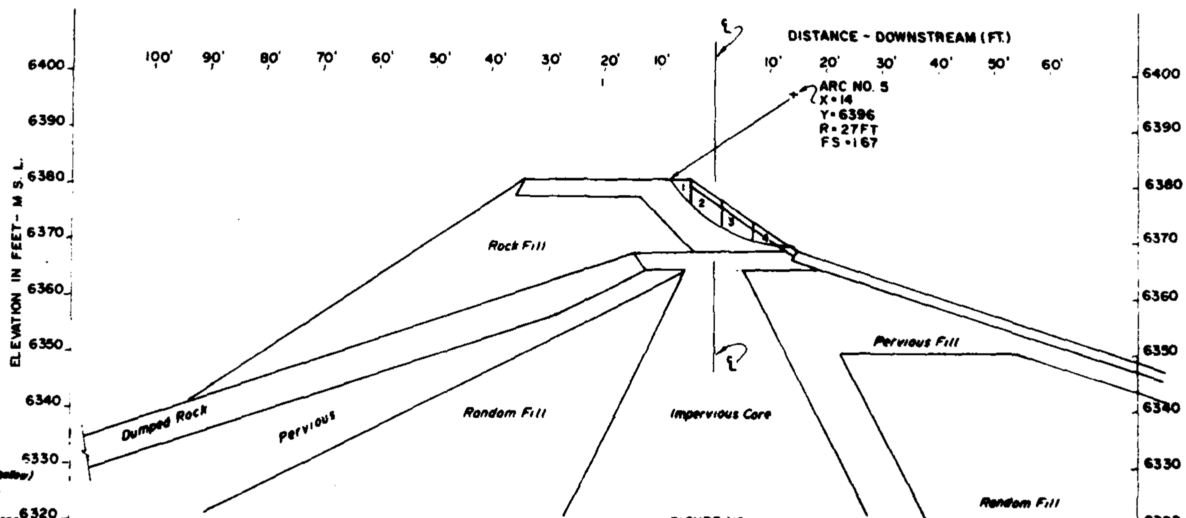


FIGURE NO.1
EMBANKMENT SECTION
WITH FAILURE ARC NO. 5
MANUAL ANALYSIS

MANUAL SOLUTION
ADOPTED DESIGN DATA
END OF CONSTRUCTION CASE

MATERIAL TYPE	UNIT WEIGHT (LBS/FT³) MOIST	γ SAT	γ SUB	S_1-STRENGTHS C(KSF)	ø
Impervious Fill	125.0	130.0	68	0.1	28°
Rock Fill and Dumped Rock	140.0	148.0	86	0	40°
Pervious Fill	140.0	148.0	86	0	35°
Random Fill	135.0	140.0	78	0	35°

MA...
ADOP...
ND OF ...
UN...
MOIST
125.0
140.0
140.0
135.0

SYMBOL	DESCRIPTION	DATE	APPROVED

REVISIONS

U.S. ARMY ENGINEER DISTRICT, LITTLE ROCK
CORPS OF ENGINEERS
LITTLE ROCK, ARKANSAS

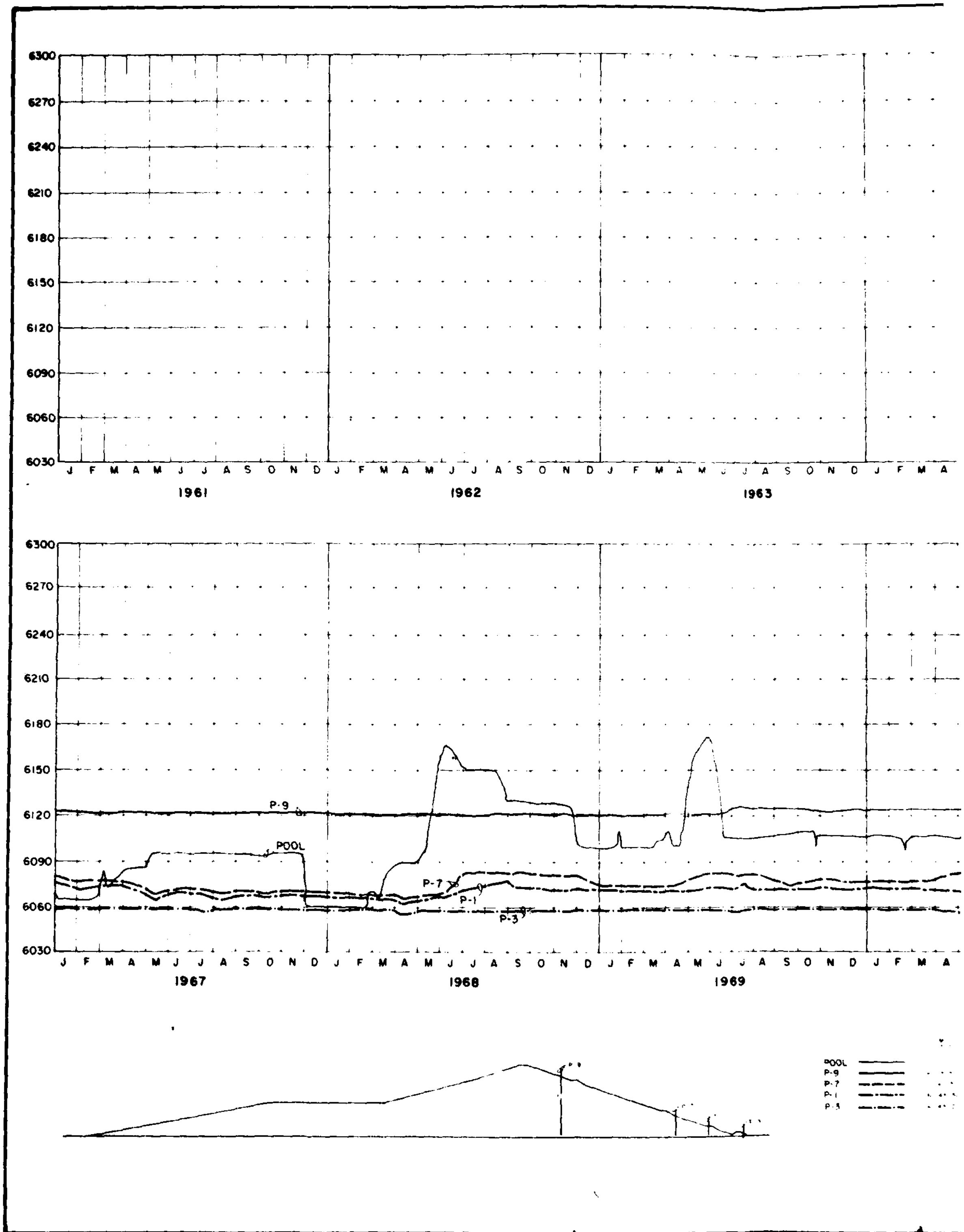
U.S. ARMY ENGINEER DISTRICT, ALBUQUERQUE
CORPS OF ENGINEERS
ALBUQUERQUE, NEW MEXICO

DESIGNED BY RLA
DRAWN BY BRB
CHECKED BY RLA
SUBMITTED BY

RIO GRANDE WATERSHED — RIO CHAMA, NEW MEXICO

ABIQUIU DAM
DAM AND SPILLWAY MODIFICATION
STABILITY ANALYSIS
END OF CONSTRUCTION
COMPUTER AND MANUAL SOLUTION

PLATE 13
FILE NUMBER RGAB-CH-DM-18
DATE MAY 1982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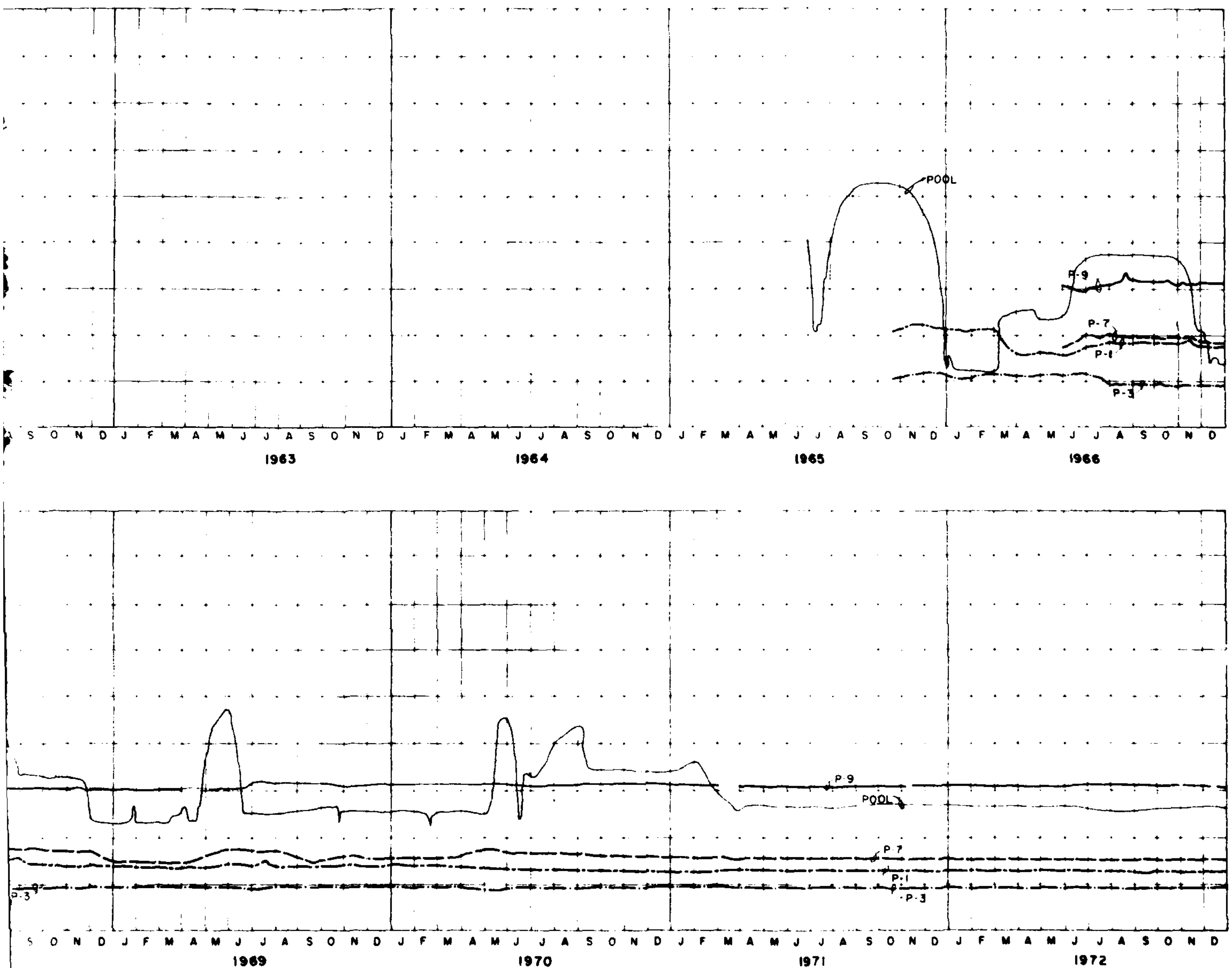
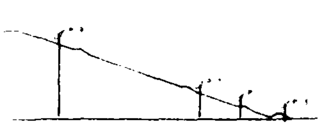
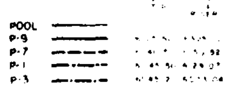
P-9
POOL
P-7
P-1
P-3
1967
1968
1969







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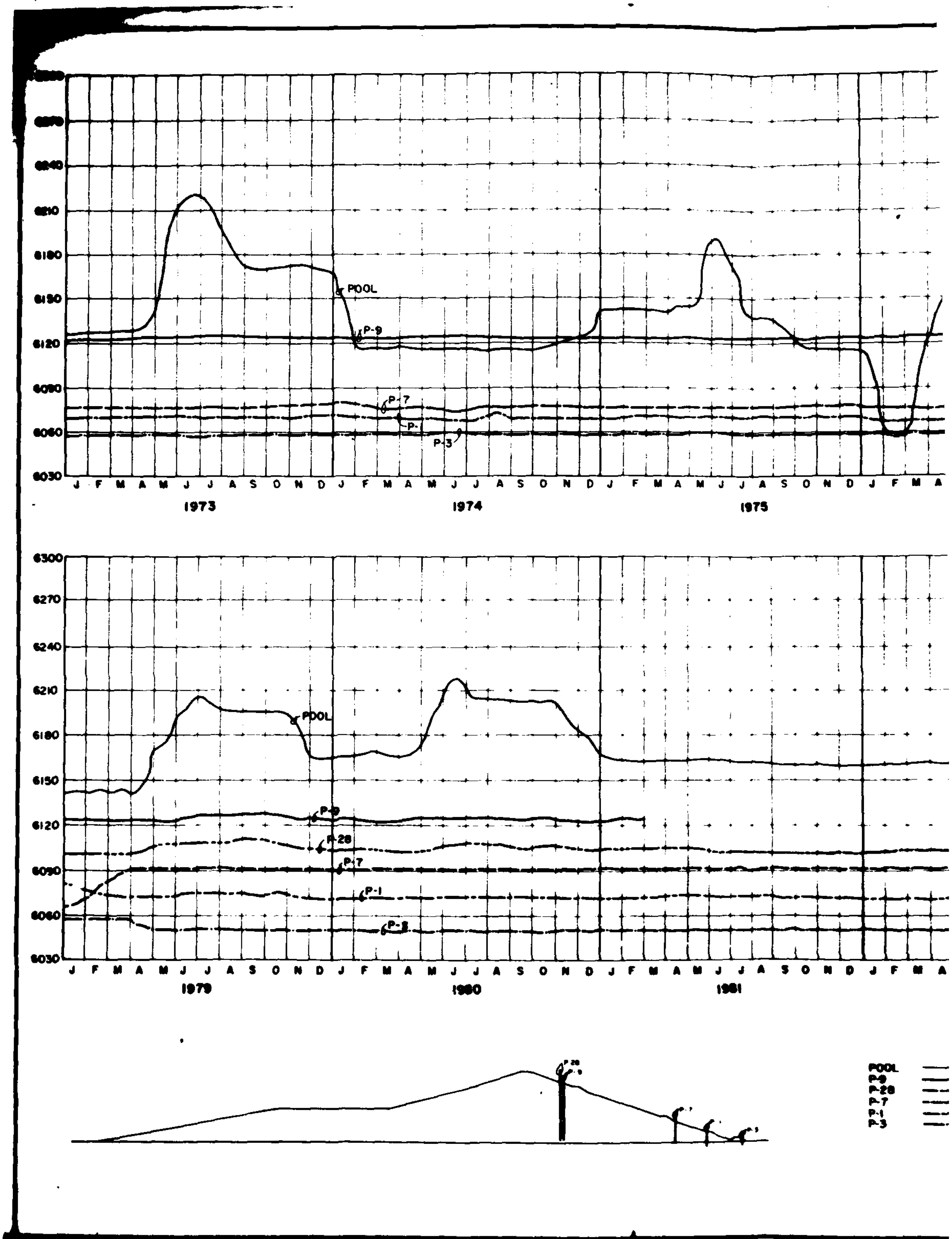
OPEN TUBE PIEZOMETER DATA

PIEZOMETERS P-9, P-7, P-1, P-3



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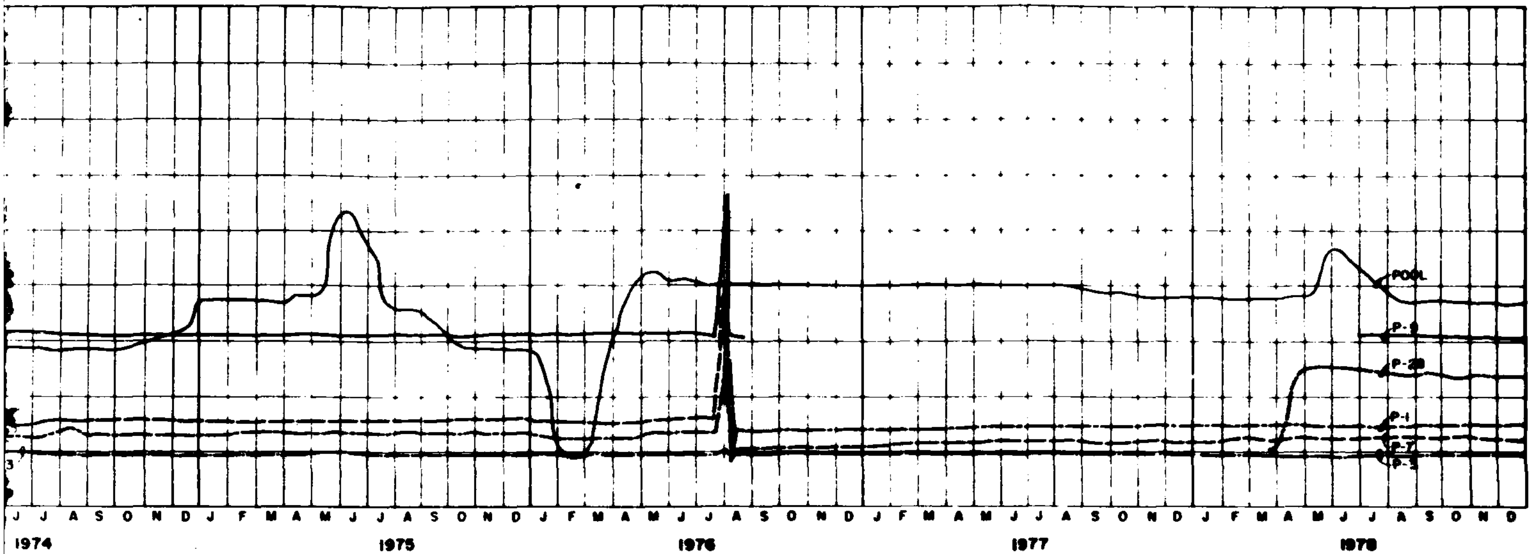
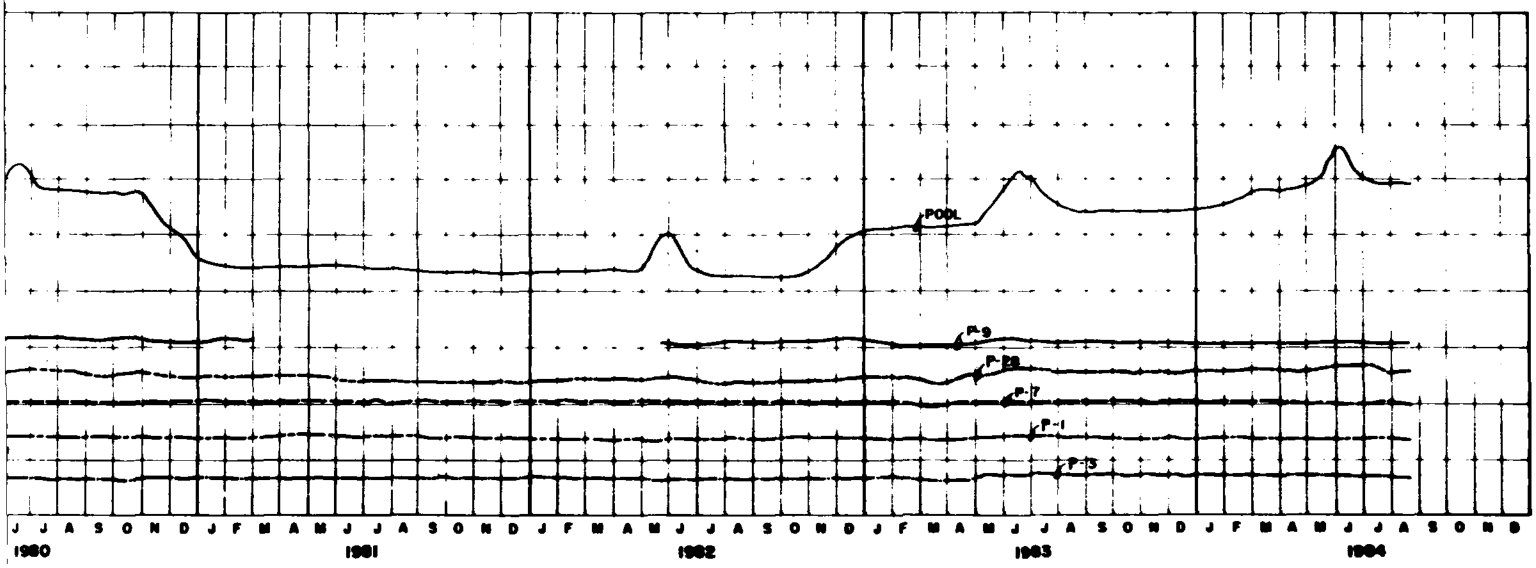
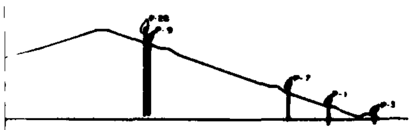
P-1
P-3







POOL
P-9
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P-3

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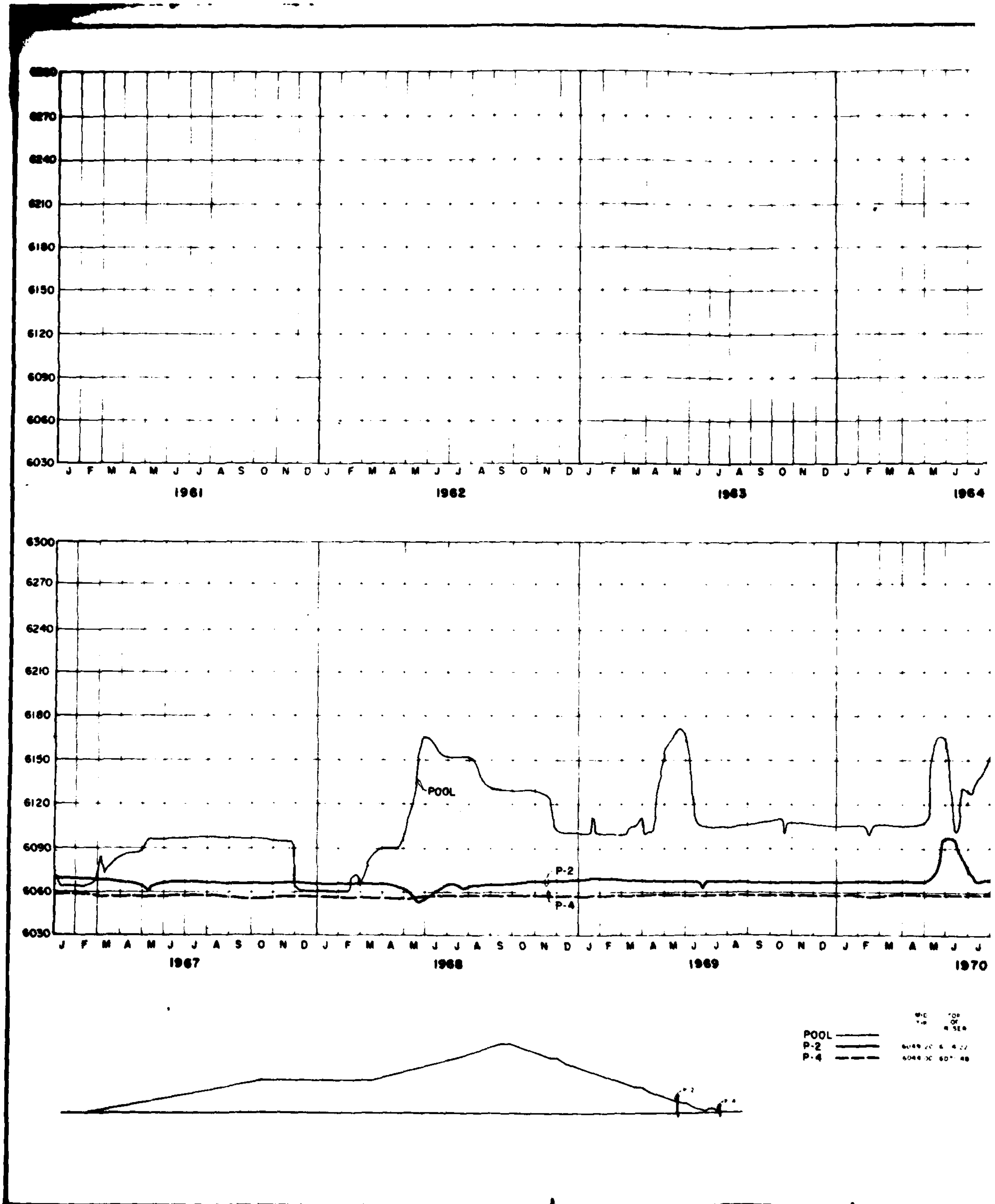

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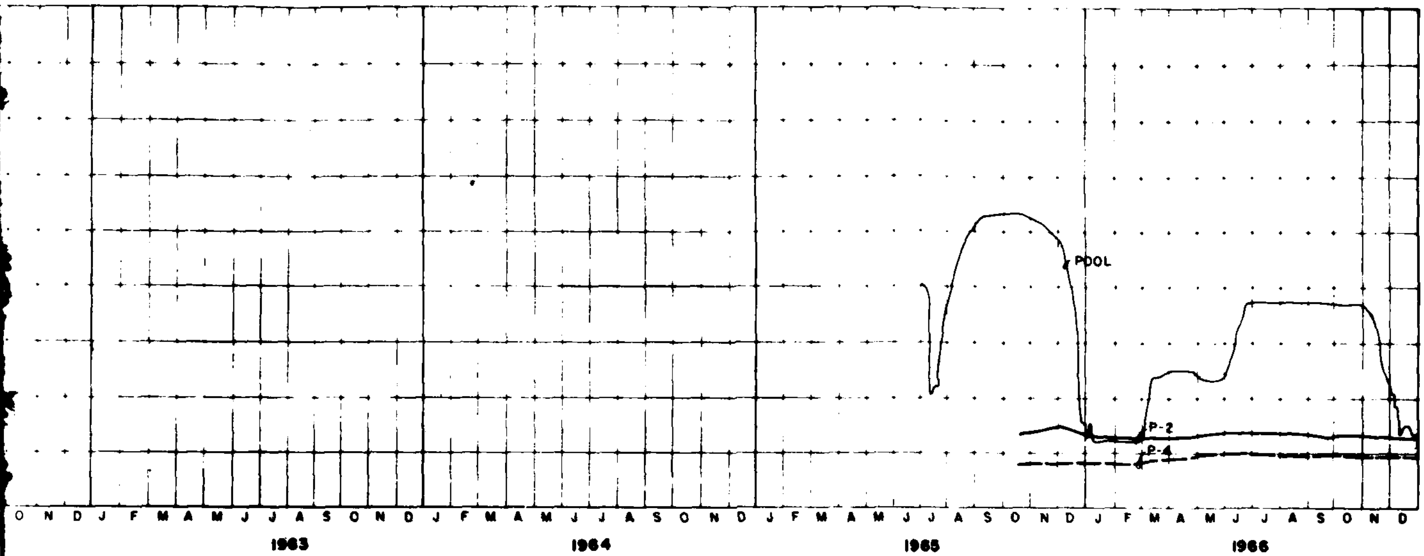
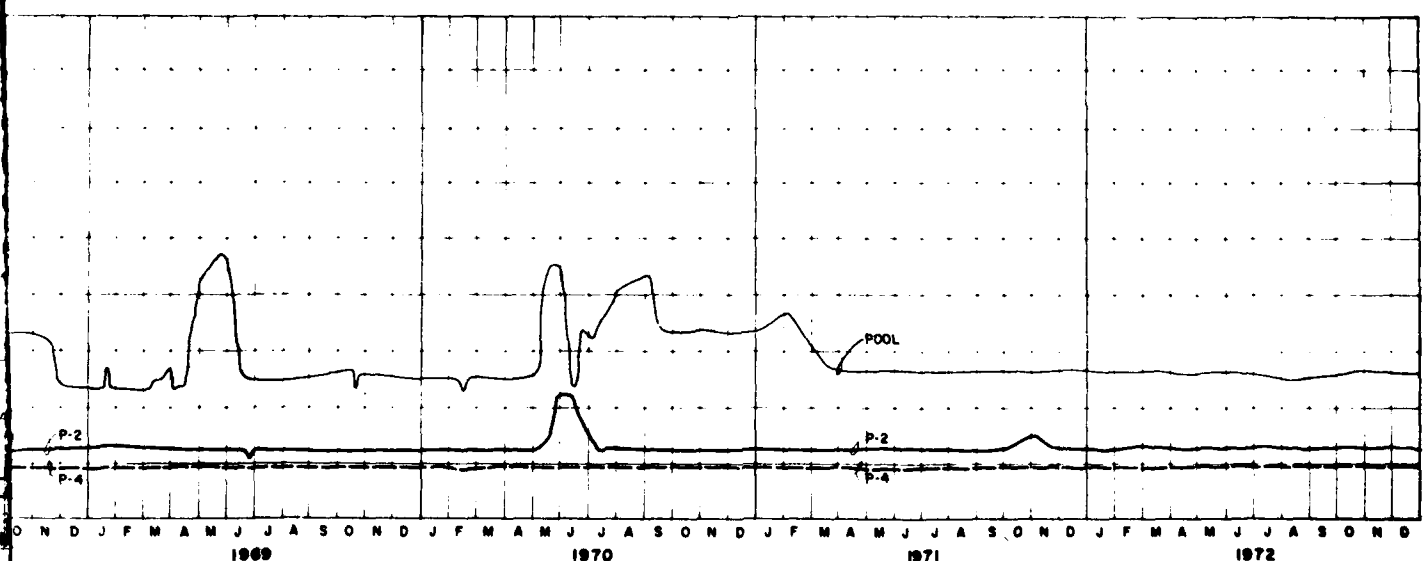
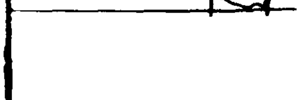




		MID TIP	TOP OF RISER
POOL	———		
P-2	———	6049.20	[illegible]
P-4	— — —	6044.00	[illegible]



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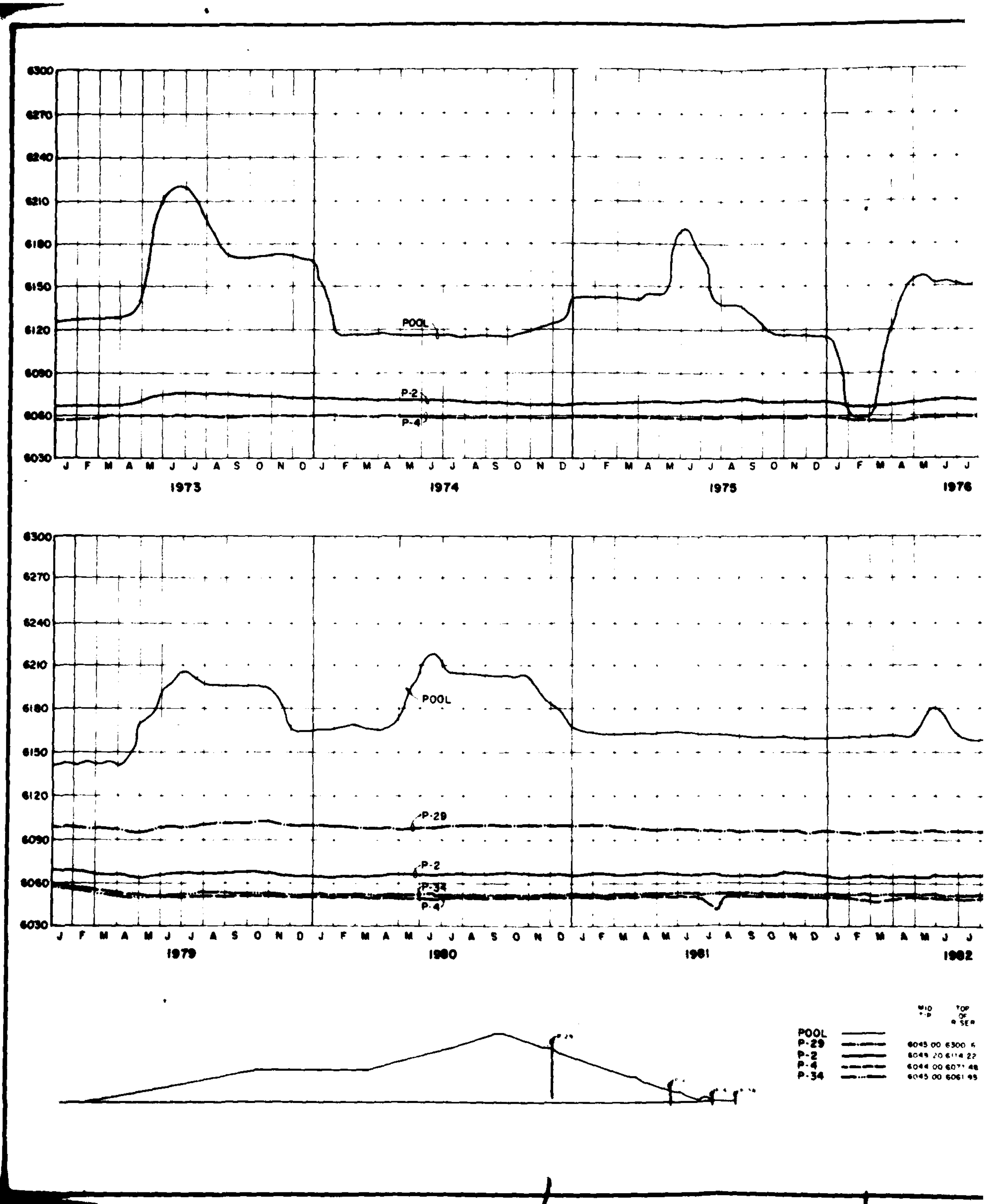

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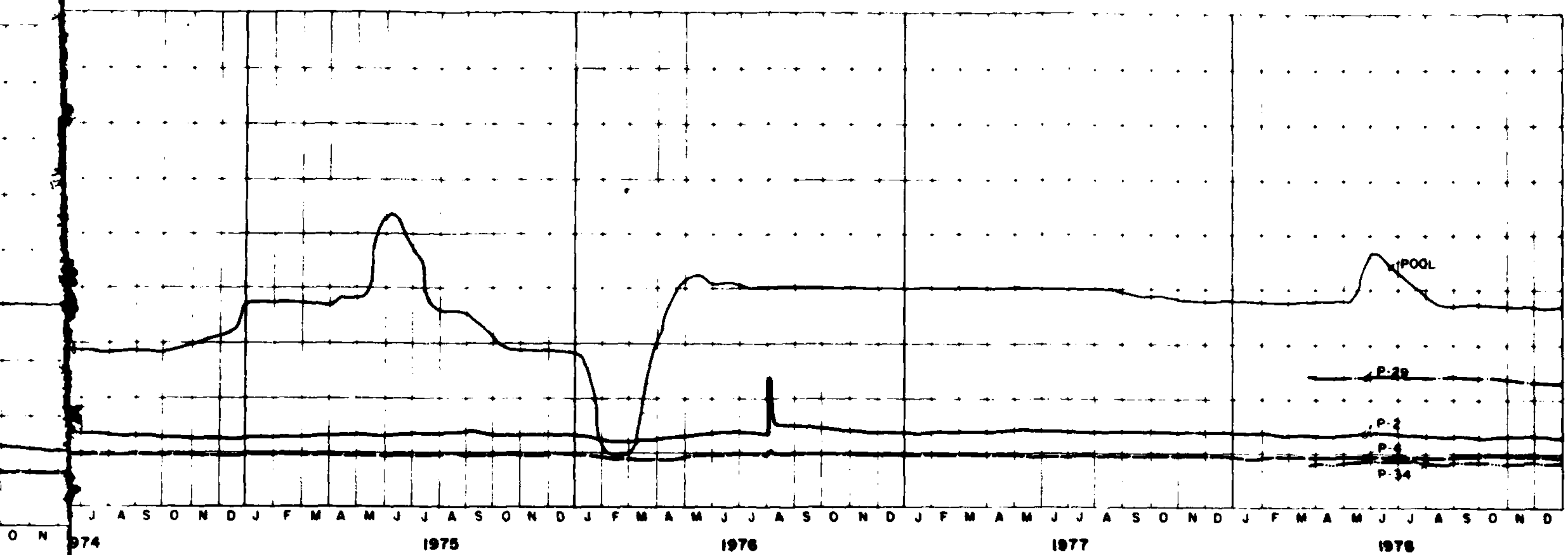

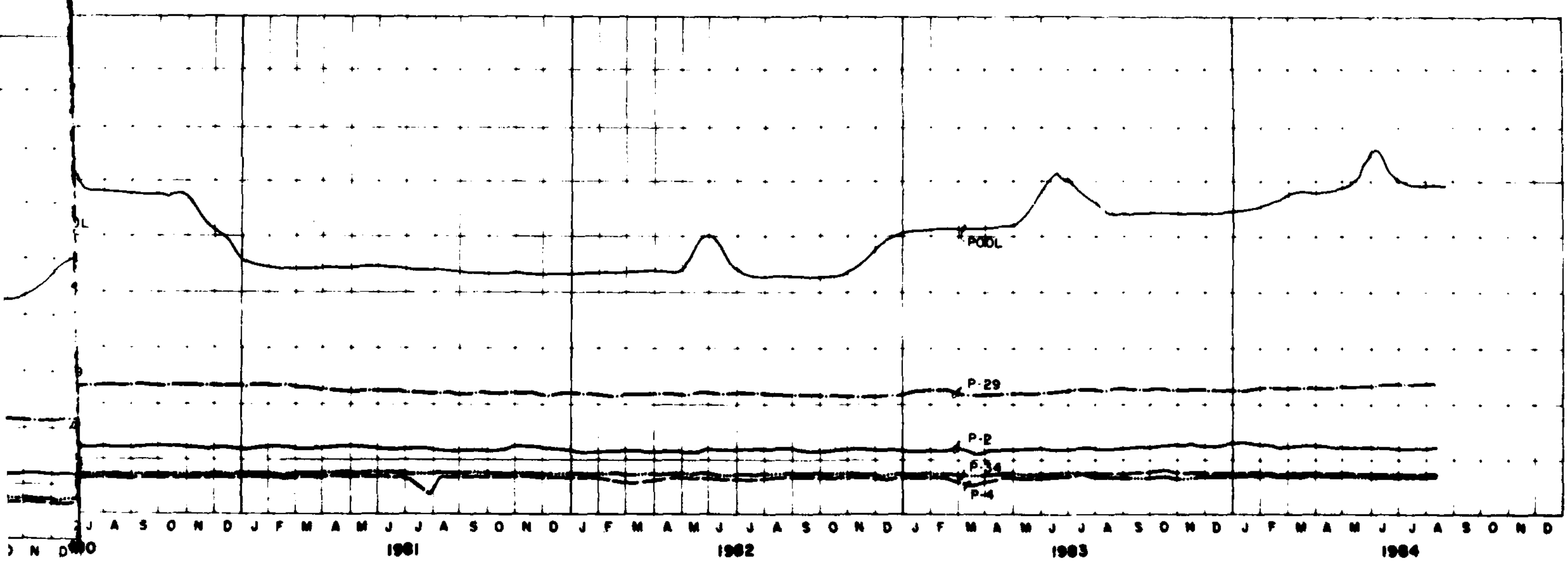

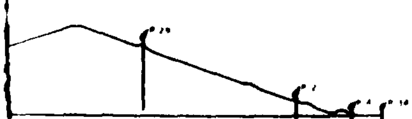

		MID TIP	TOP OF RISER
POOL	———		
P-29	—·—·—	6045.00	6300.6
P-2	———	6049.20	6114.22
P-4	— — —	6044.00	6071.48
P-34	—··—	6045.00	6061.95

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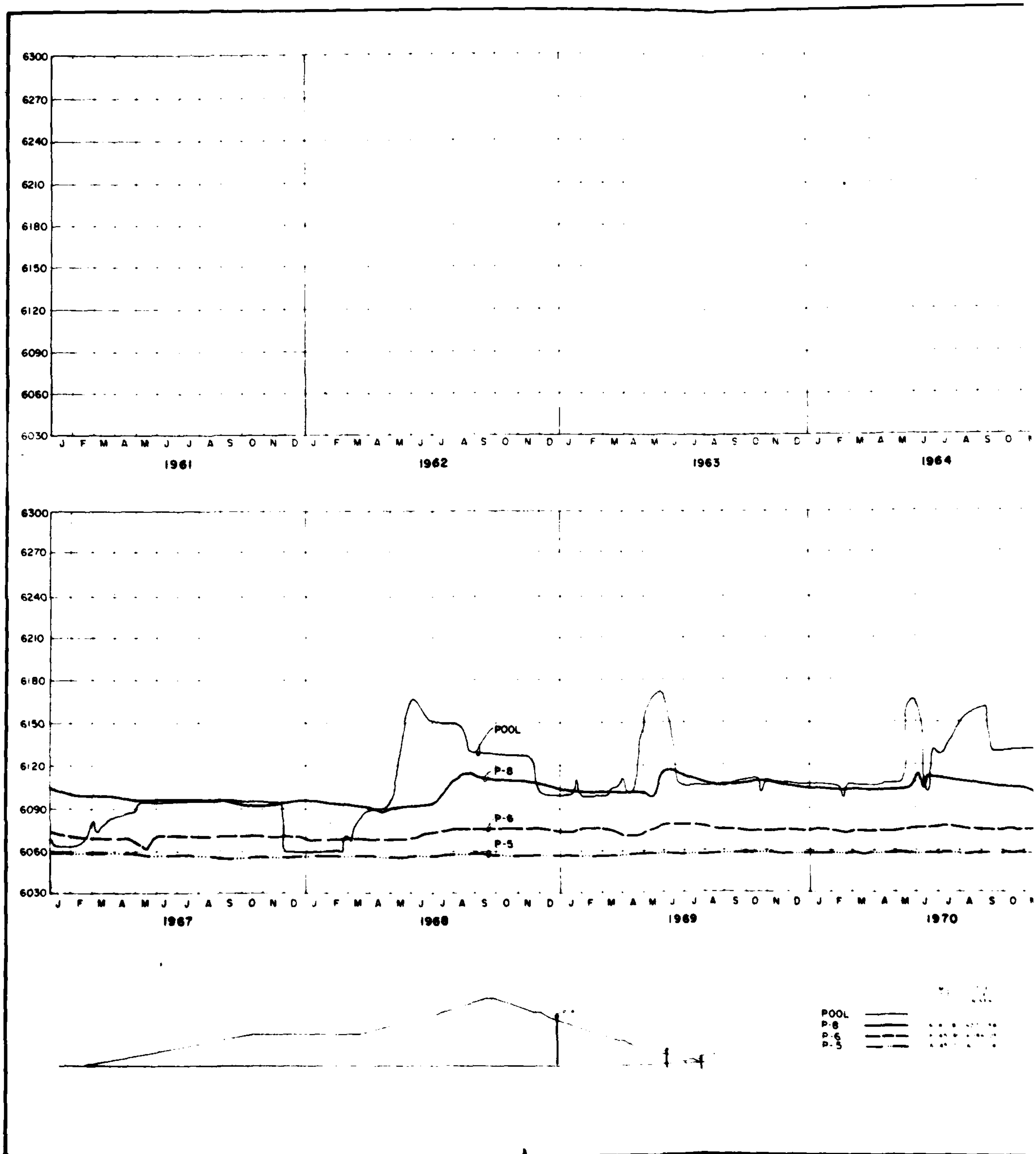
PIEZOMETERS P-29, P-2, P-4, P-34



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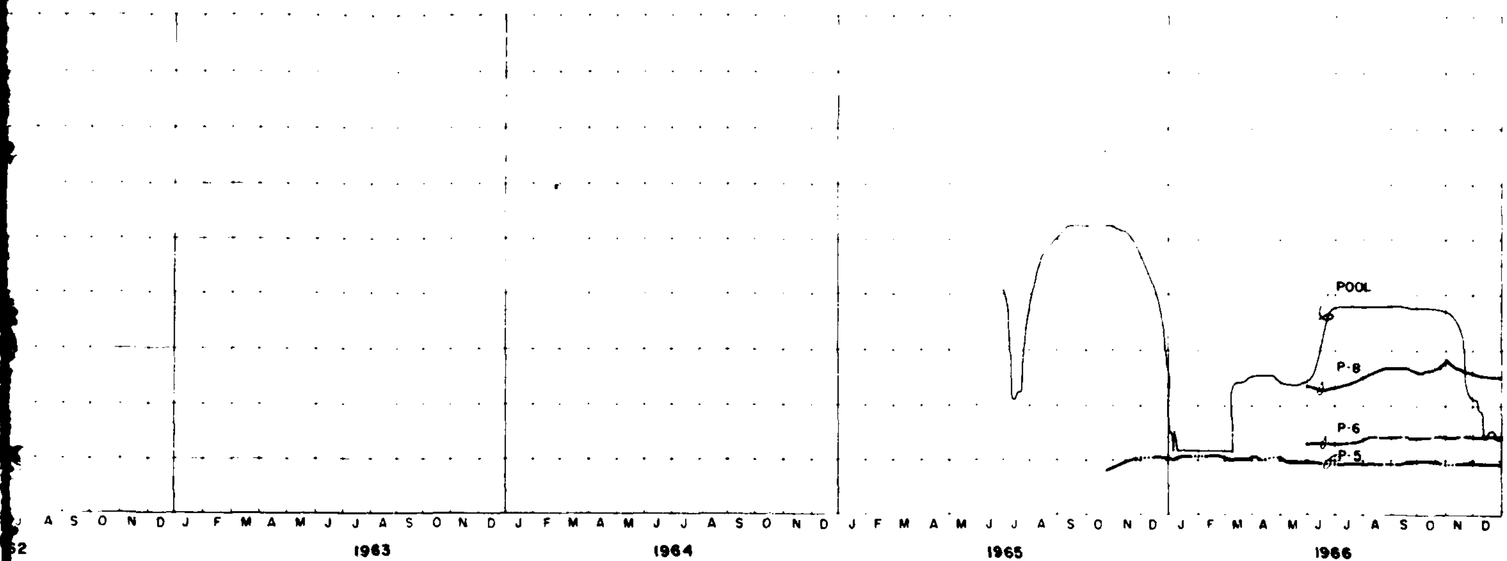
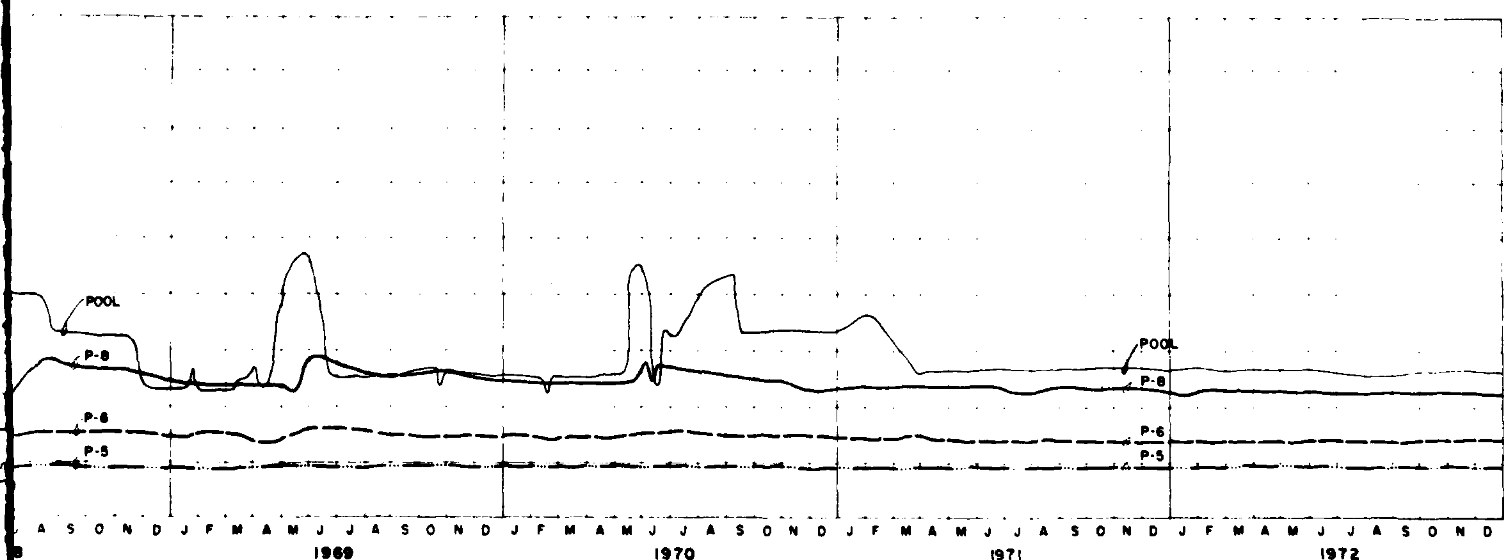
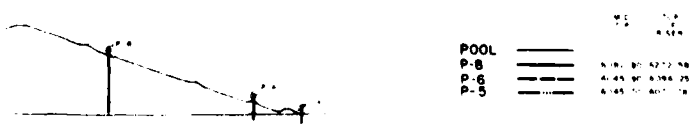
P-6
P-5







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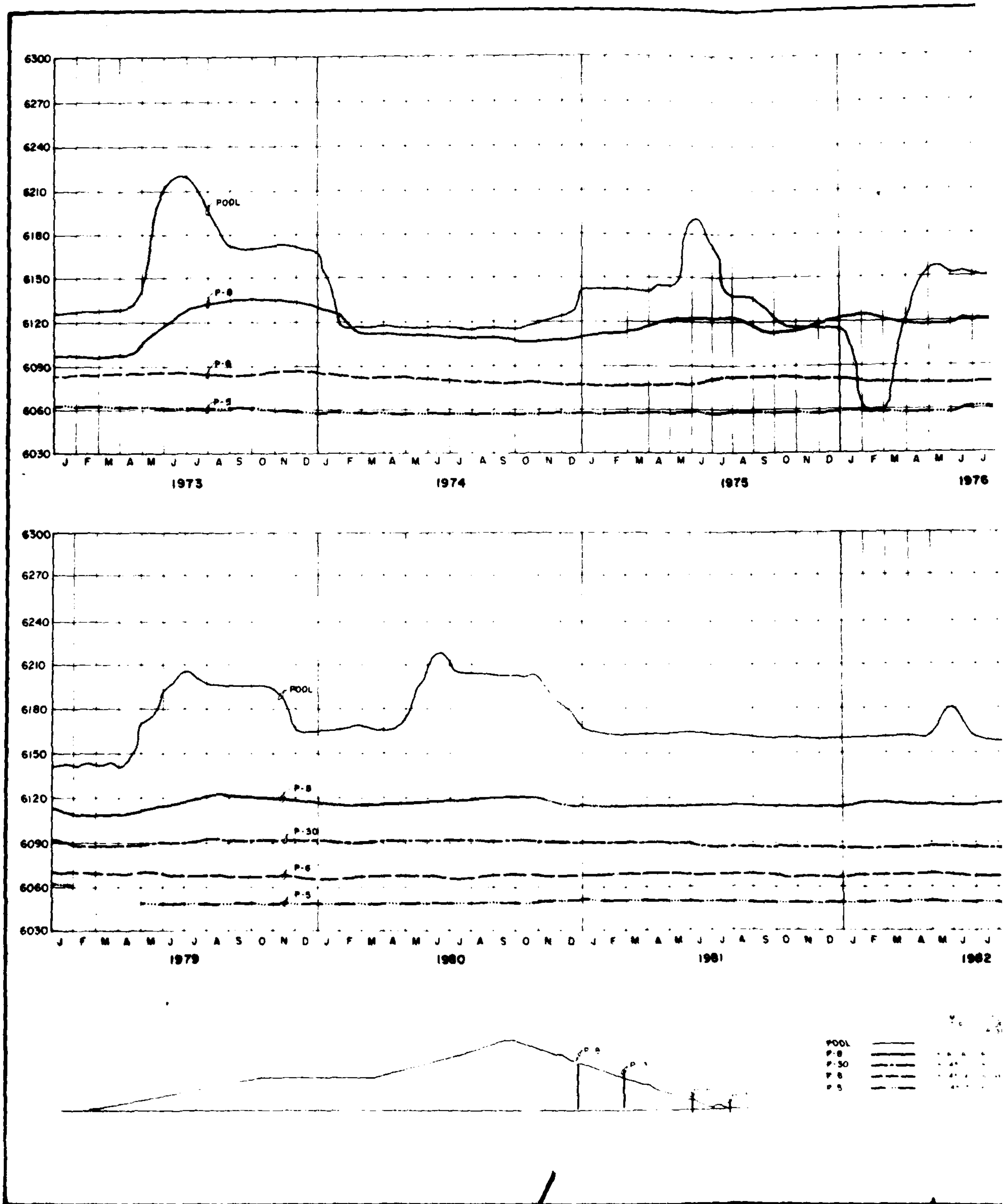
PIEZOMETERS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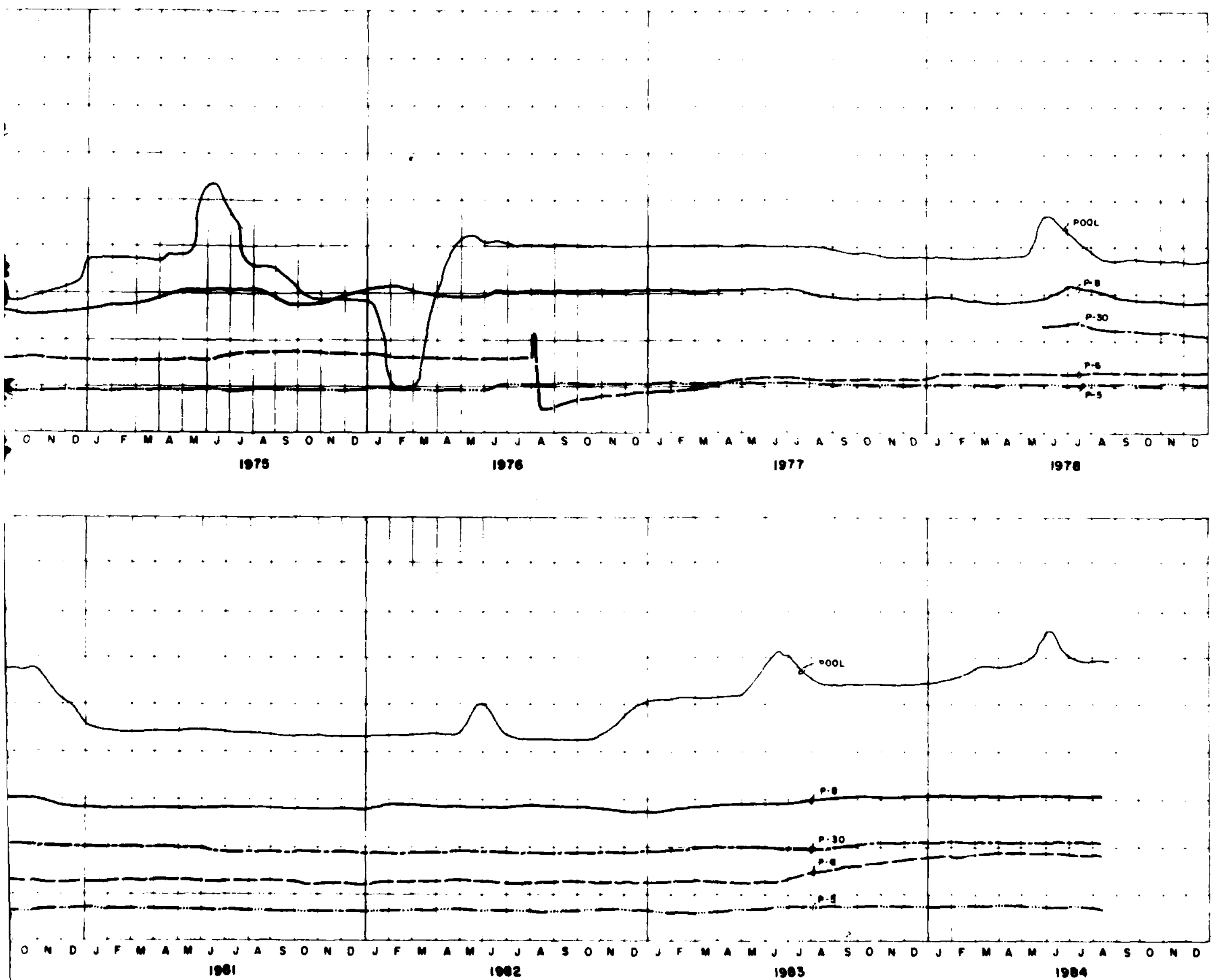

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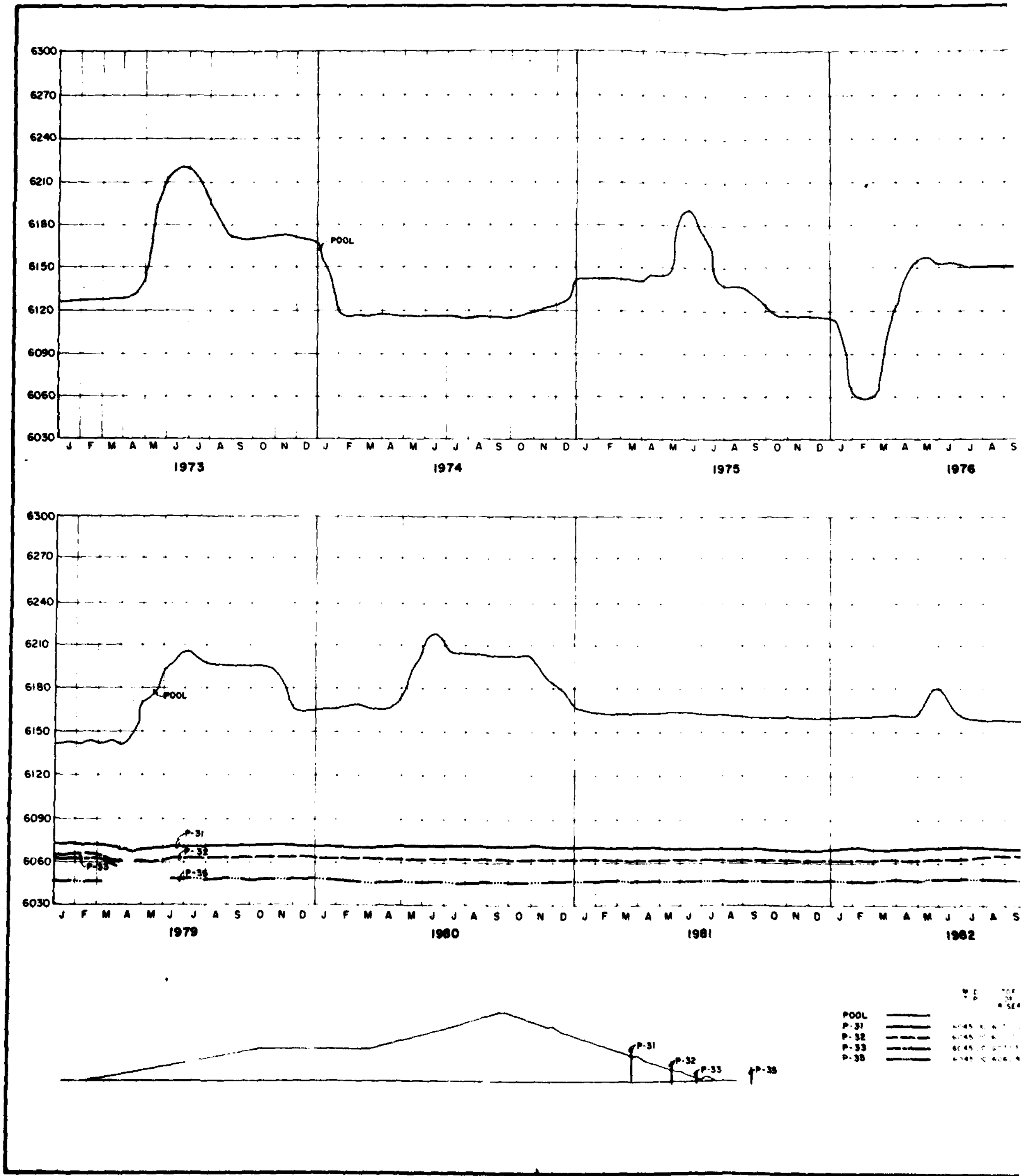
PIEZOMETERS P-



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POOL
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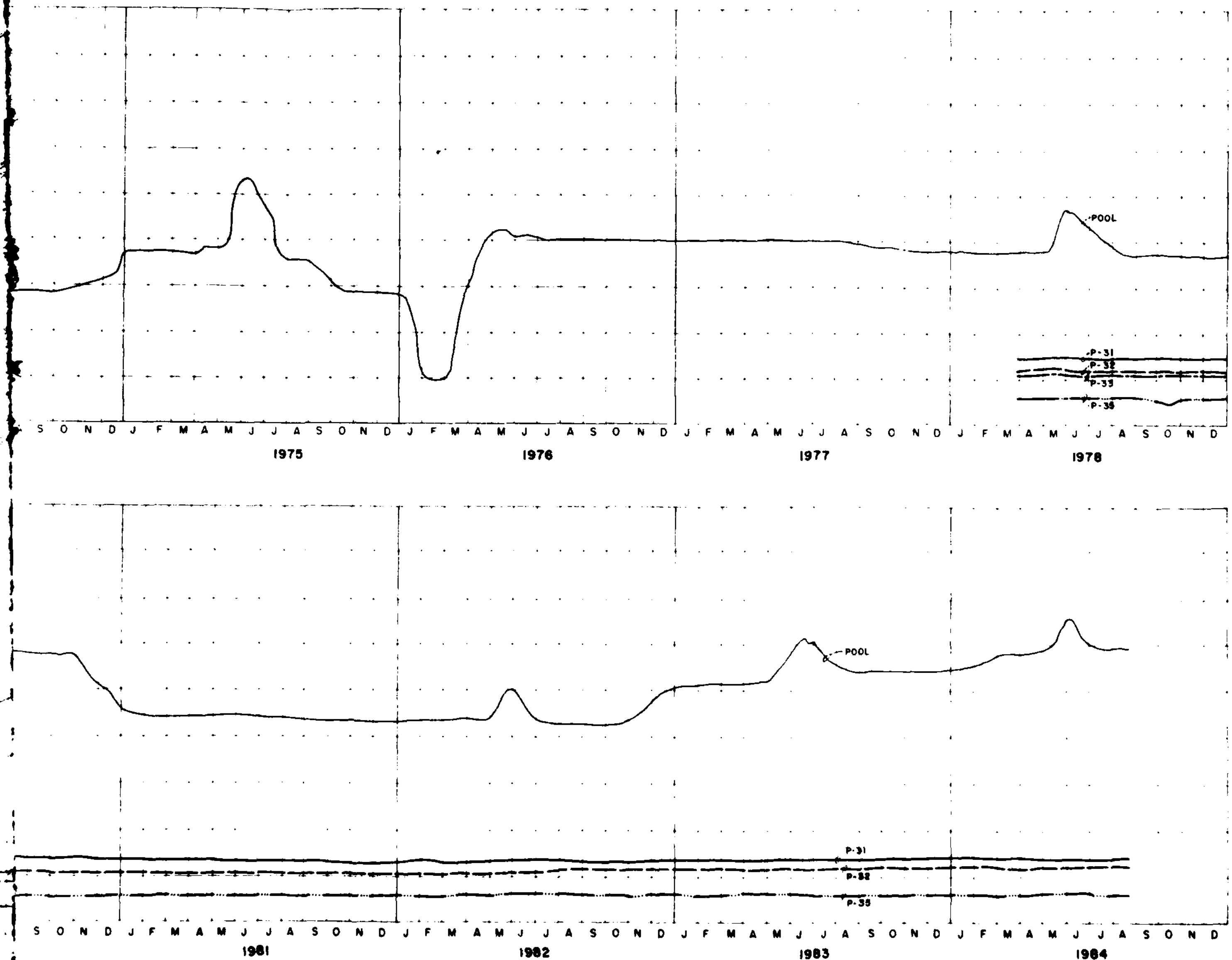

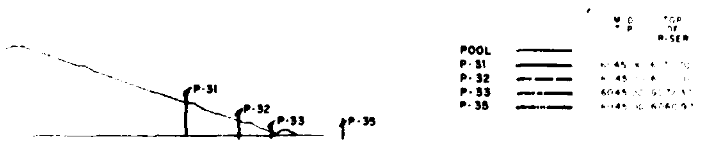

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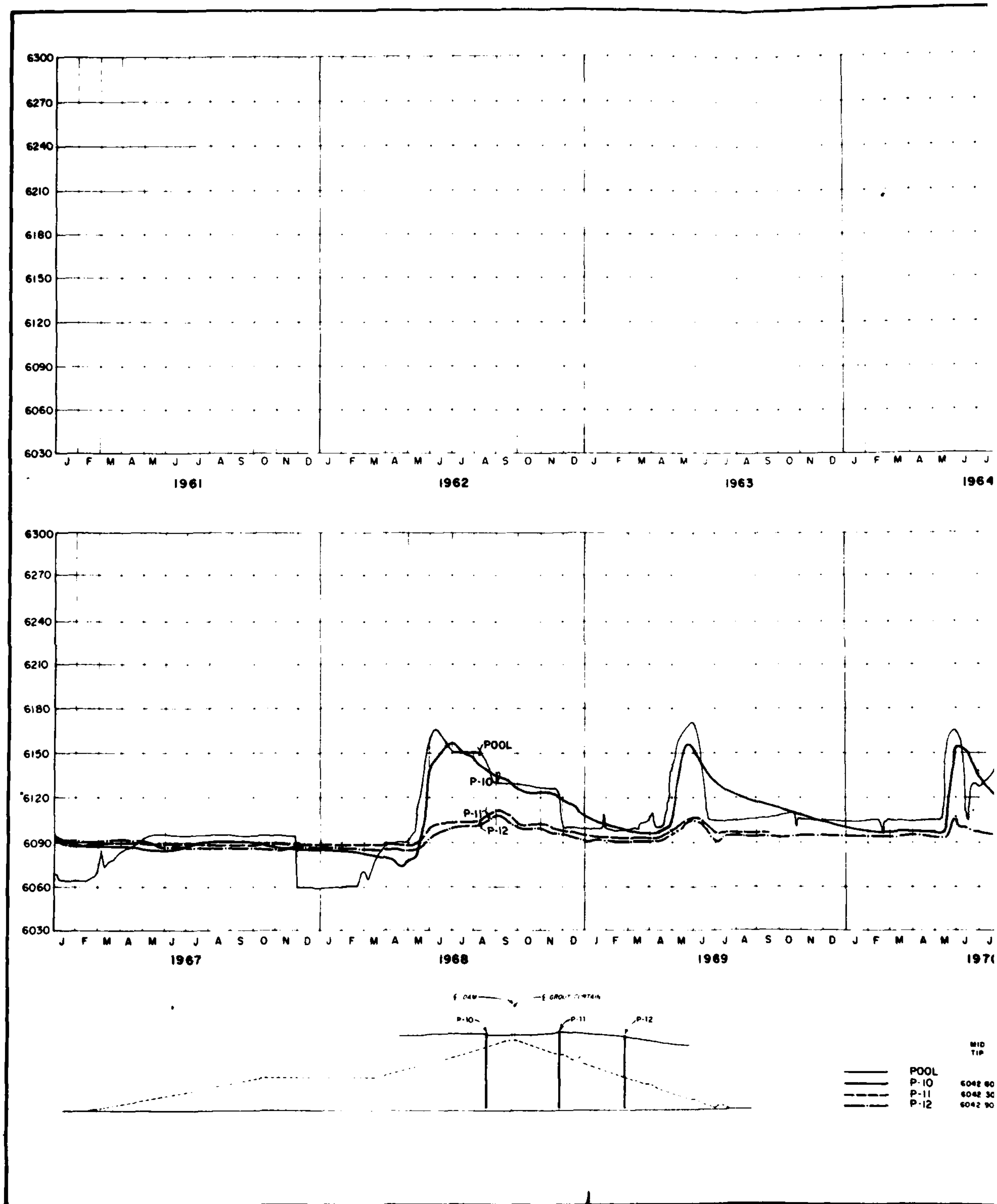
PIEZOMETERS P-31 P-32 P-33 P-35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POOL
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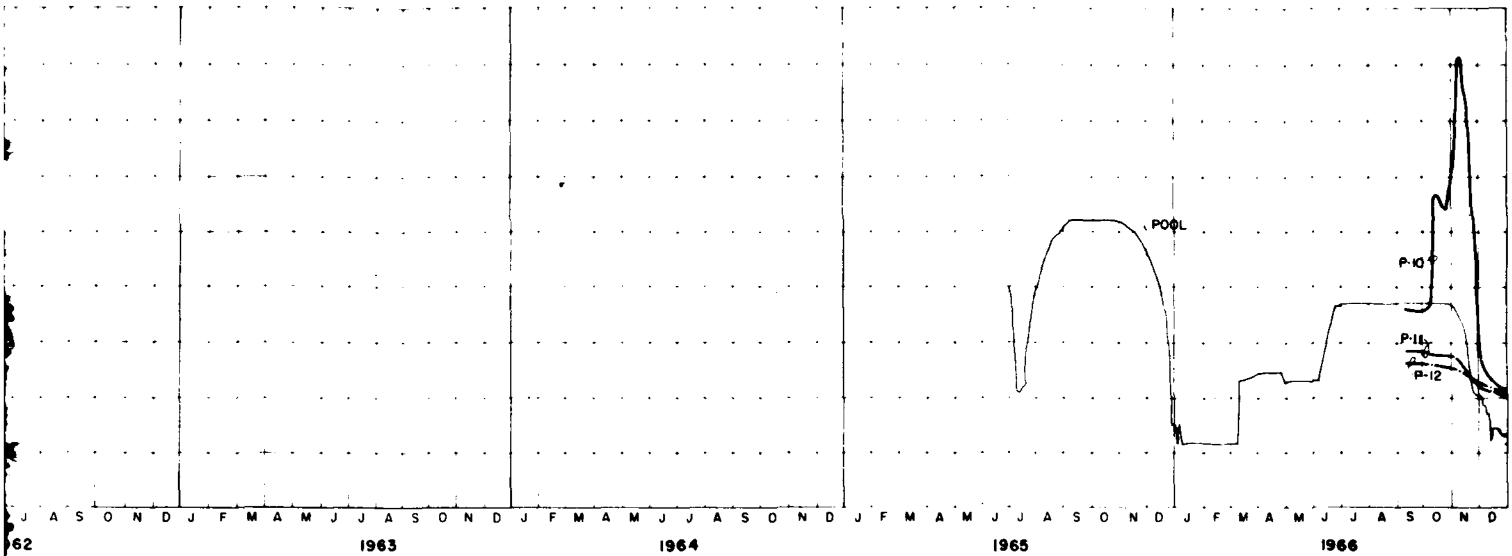
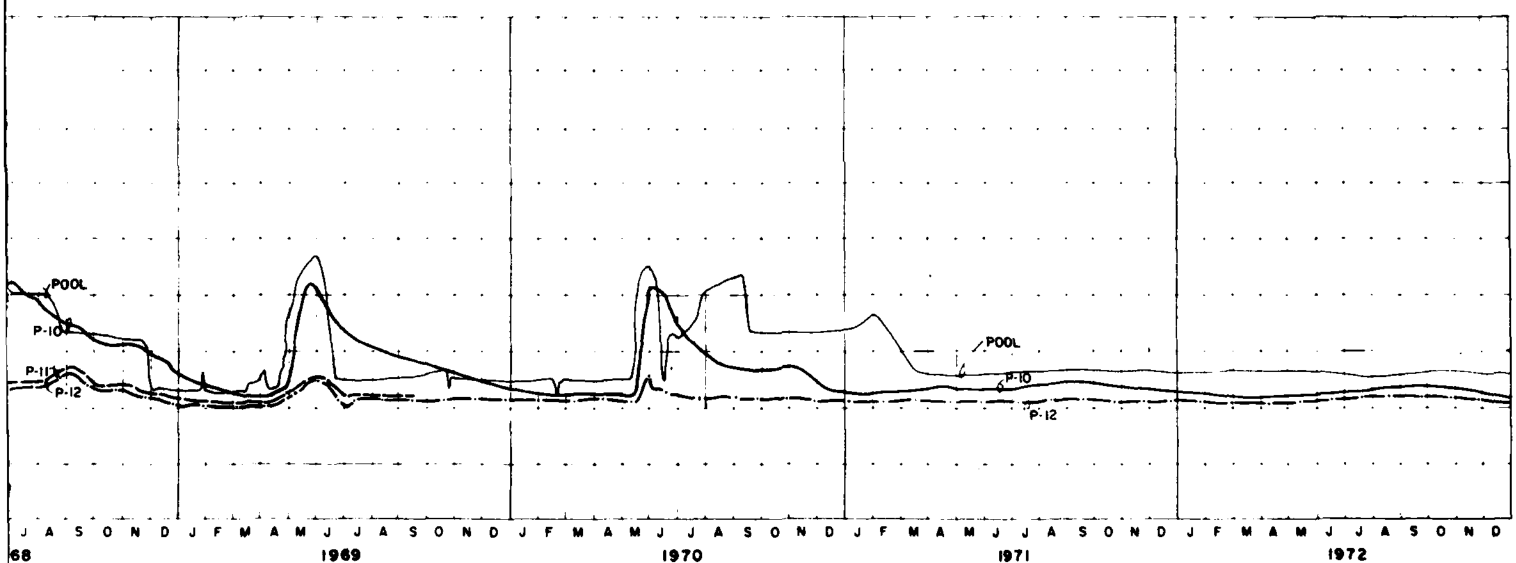
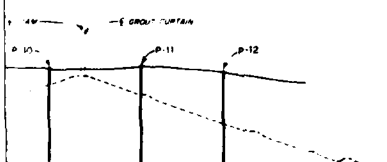
P-12







		MID TIP	TOP OF RISER
———	POOL		
———	P-10	6042 60	6394 71
– – – –	P-11	6042 30	6400 25
—·—·—	P-12	6042 90	6379 90

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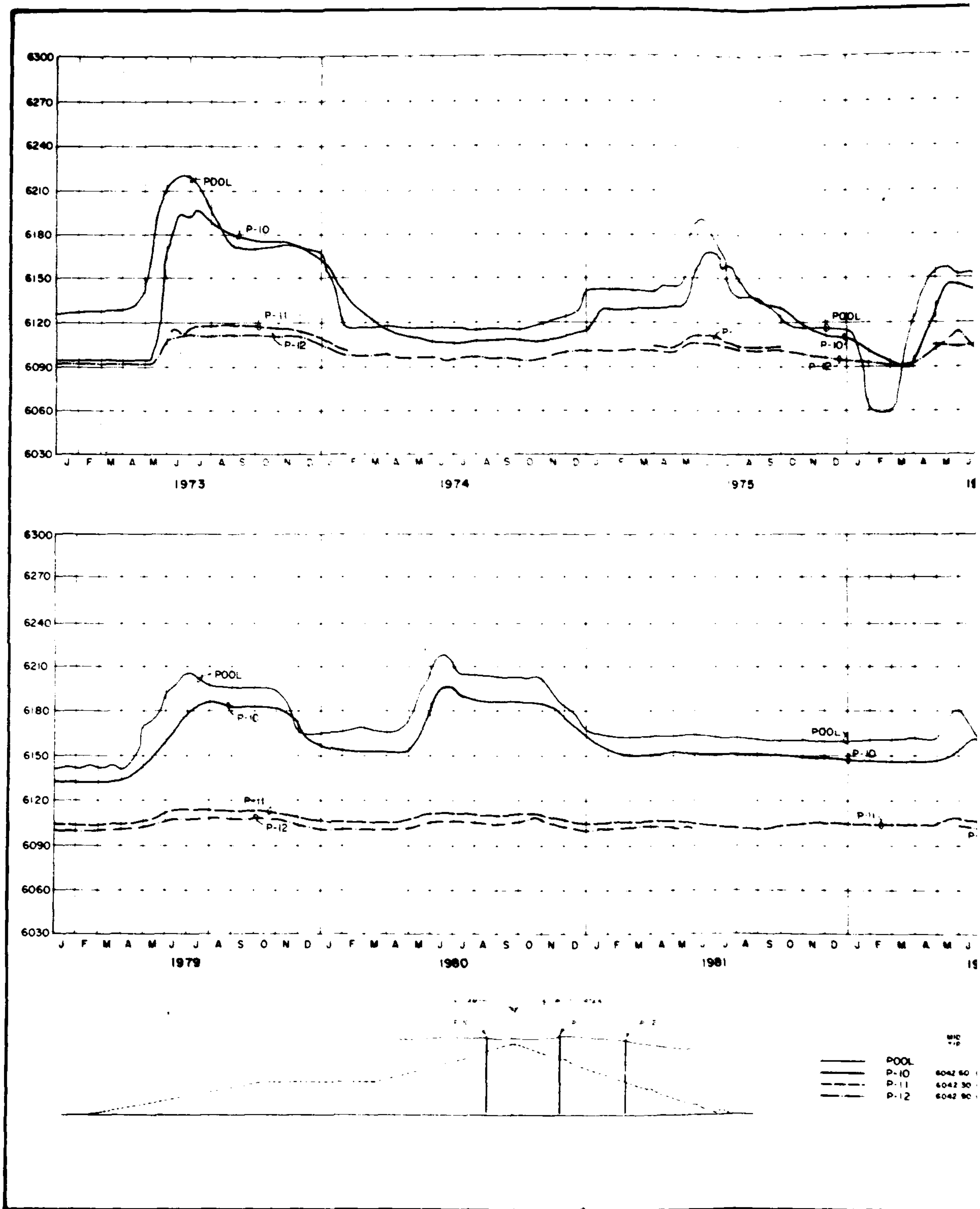
PIEZOMETERS P-10, P-11, P-12



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J F M A M J J A S O N D
1973
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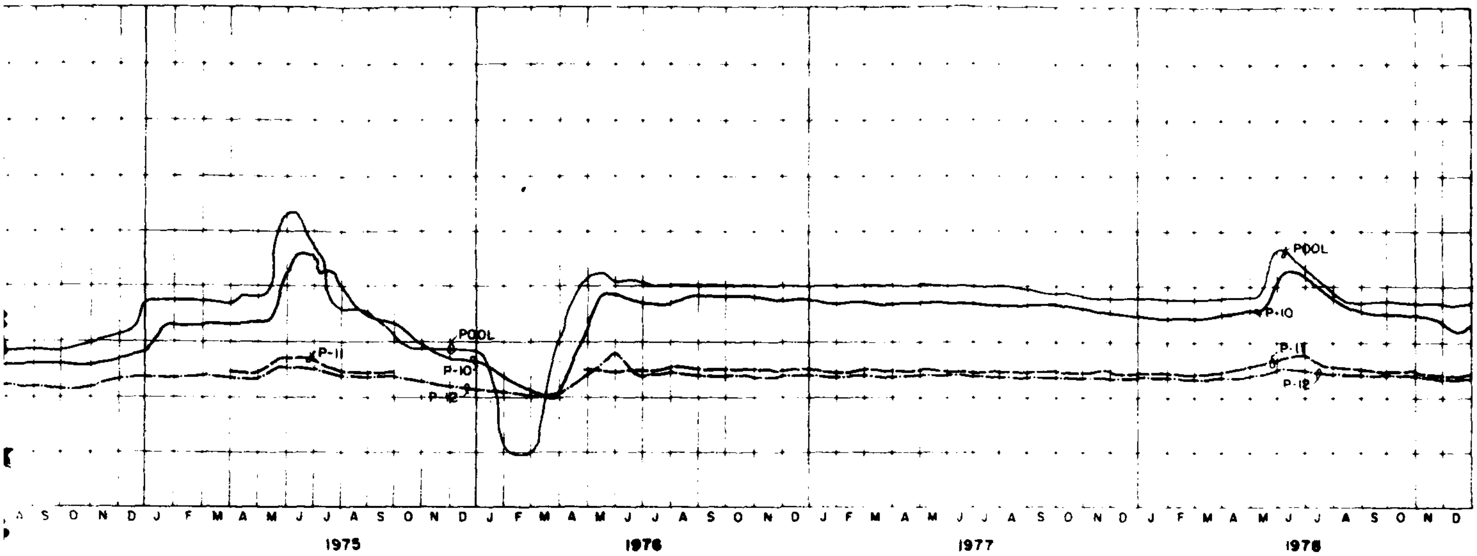
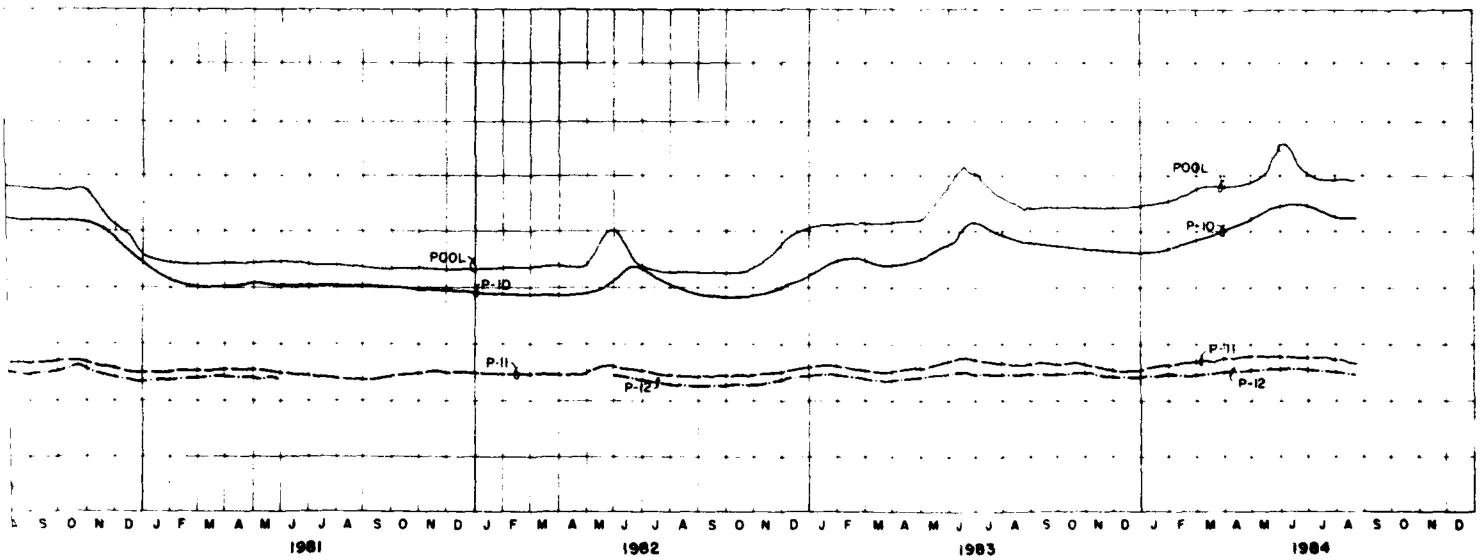
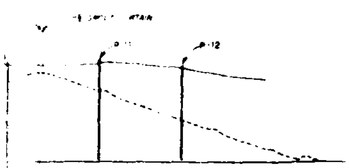
1980
1981
POOL
P-10
P-11
P-12







		MID TIP	TOP OF RISER
——	POOL		
——	P-10	6042 60	6394 71
– – –	P-11	6042 30	6400 25
—·—	P-12	6042 90	6379 90

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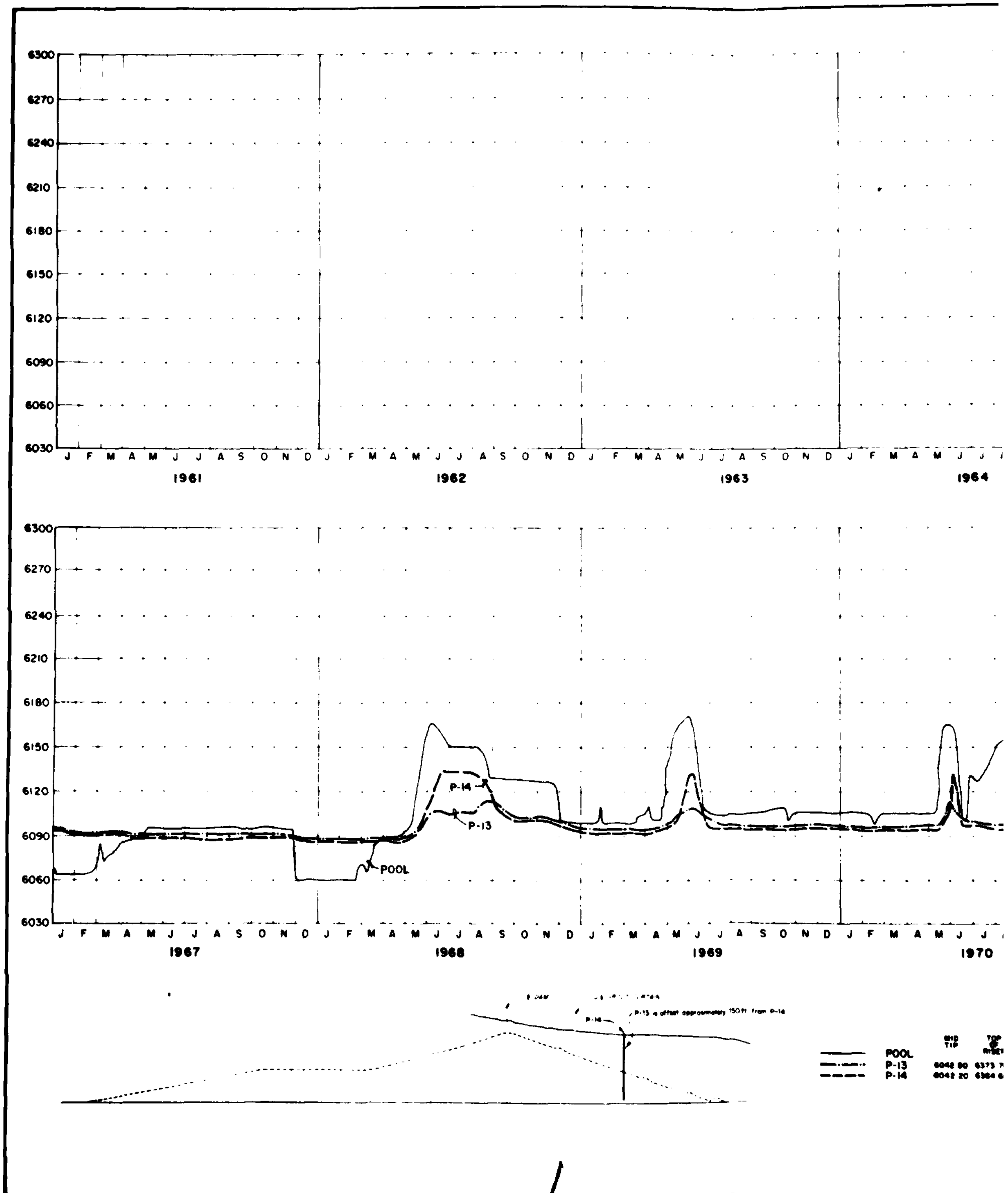
EMBANKMENT CRITERIA AND PERFORMANCE REPORT

OPEN TUBE PIEZOMETER DATA

PIEZOMETERS P-10, P-11 & P-12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J F M A M J J A S O N D
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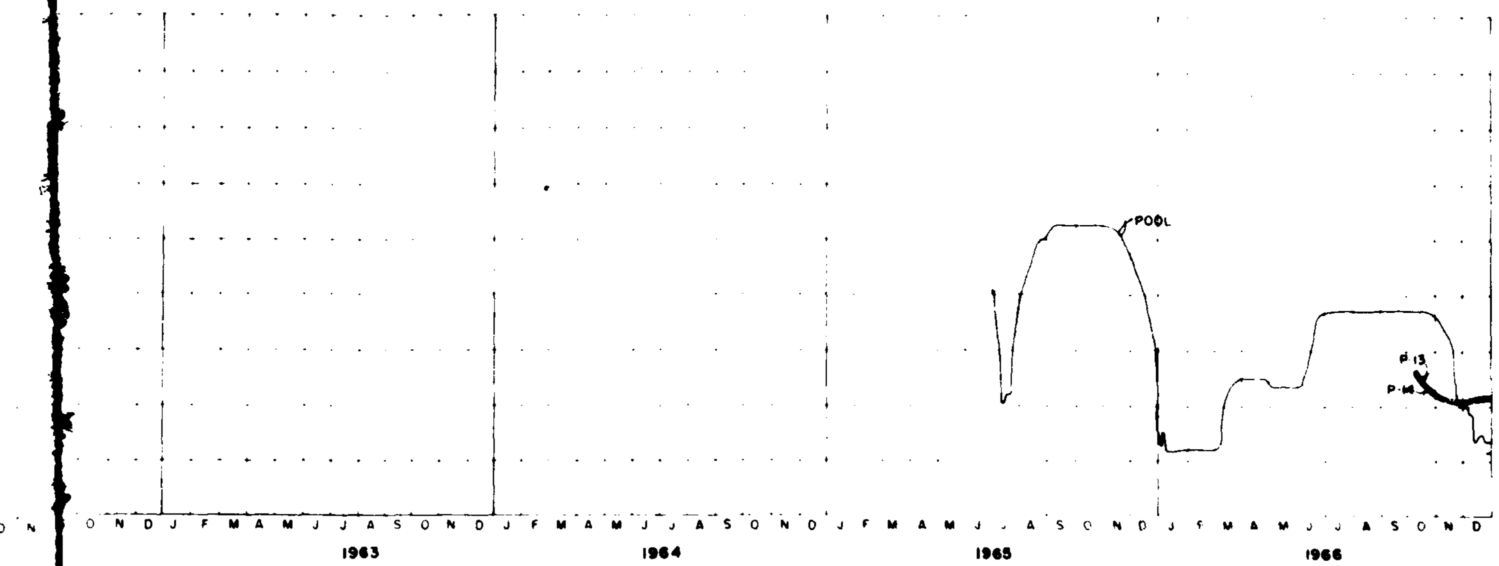
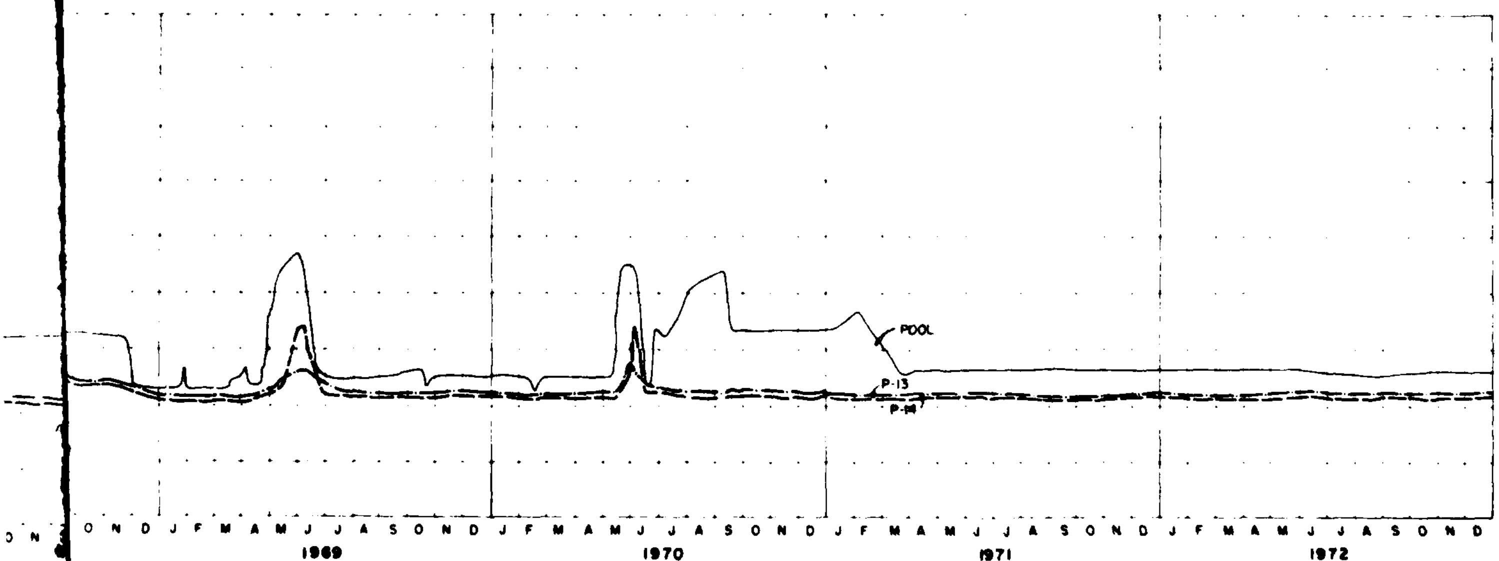
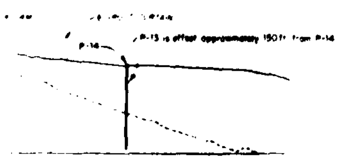
1964
1967
1968
1969
1970
P-14
P-13
POOL
P-13 is offset approximately 150 ft from P-14
P-14
POOL
P-13
P-14
TIP
6042 80
6042 20







		TIP	TOP OF RISER
———	POOL		
—·—··	P-13	6042 80	6373 76
— — —	P-14	6042 20	6364 60

US ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
TULSA OKLAHOMA

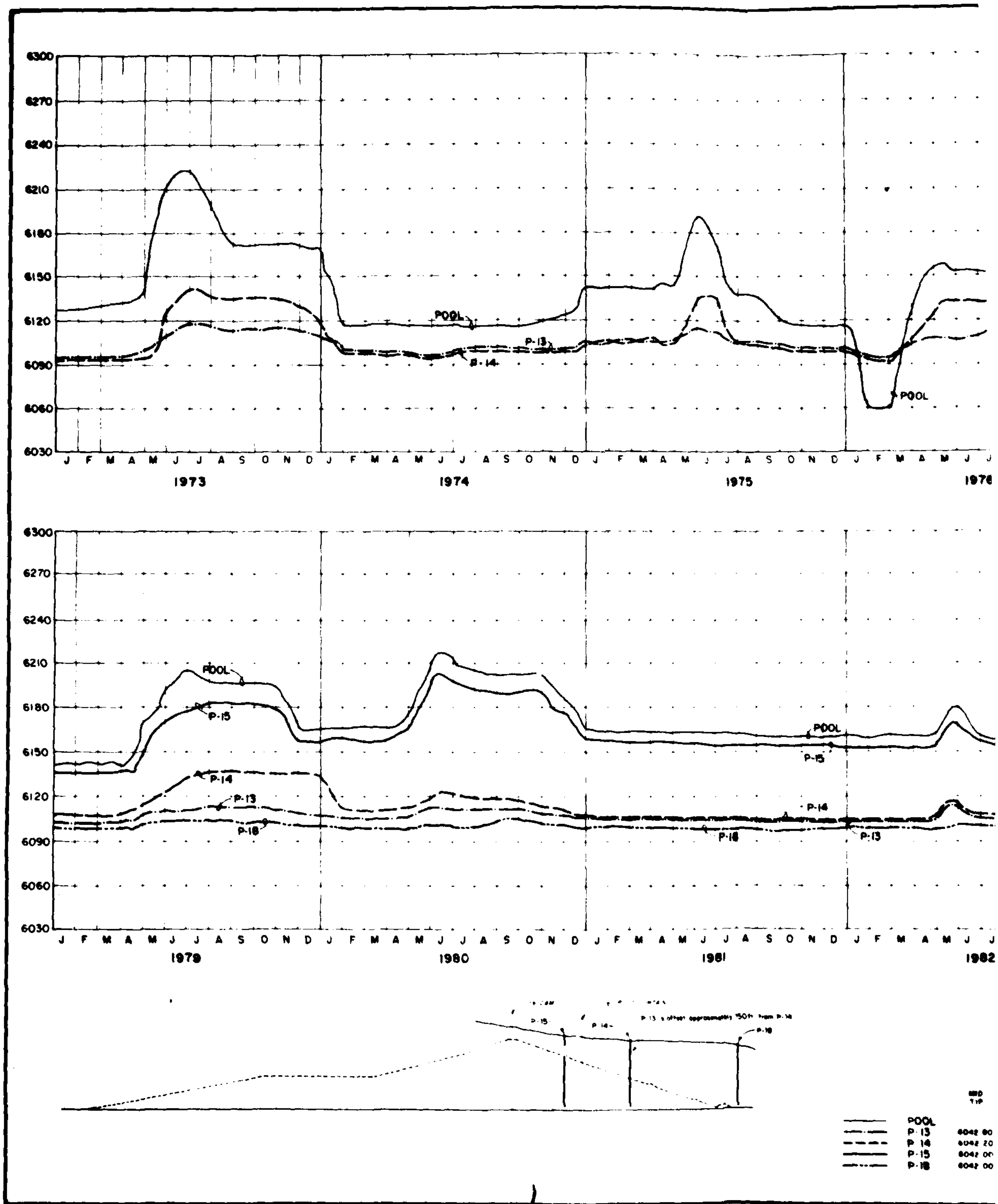
US ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ALBUQUERQUE, NEW MEXICO

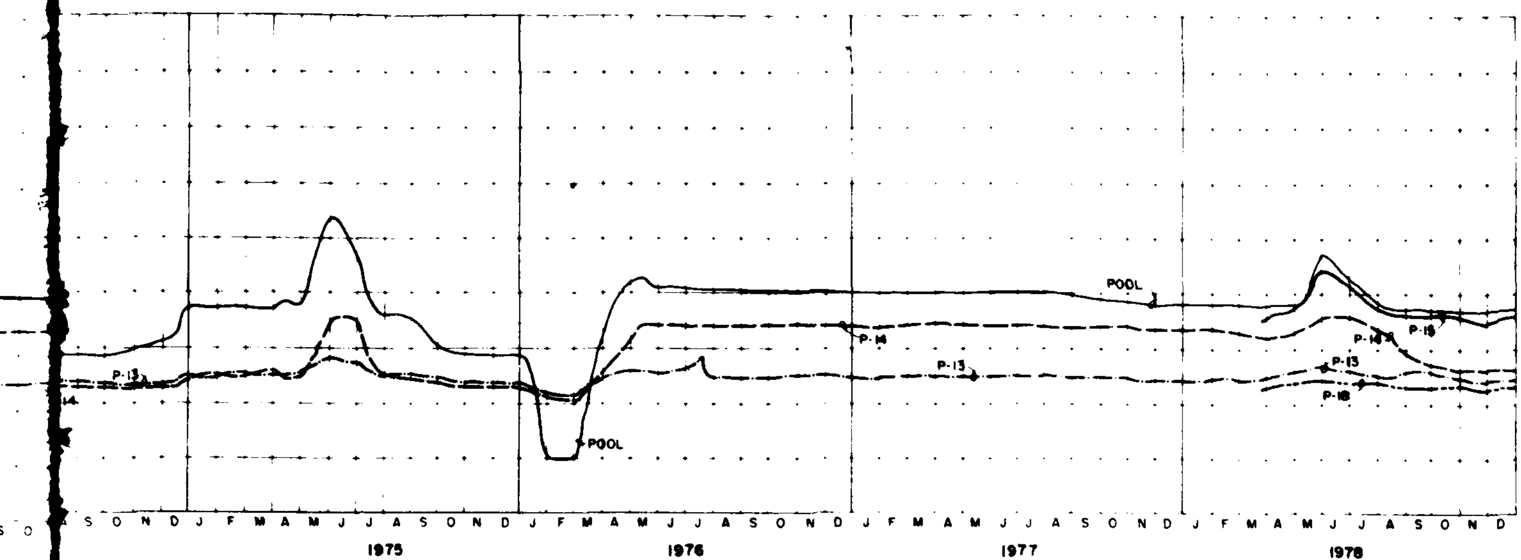
ABIQUIU DAM

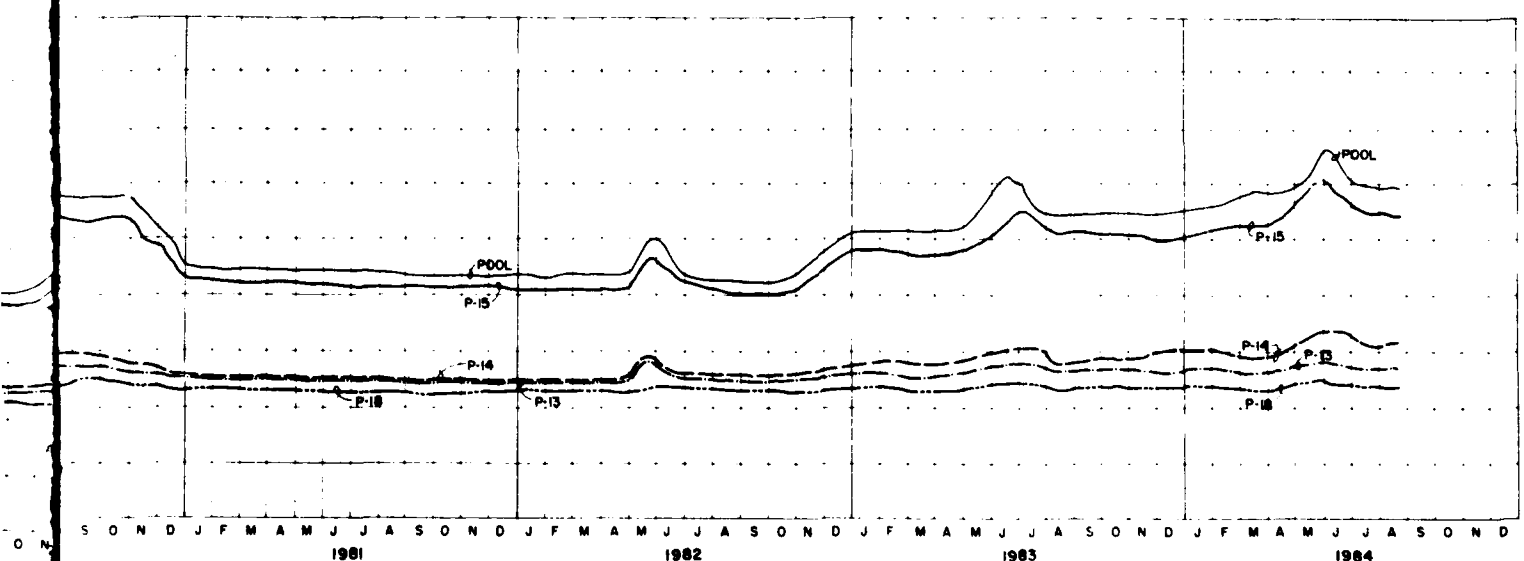
RIO GRANDE WATERSHED, RIO CHAMA
RIO ARRIBA COUNTY, NEW MEXICO

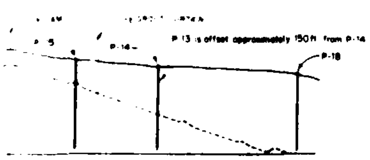
EMBANKMENT CRITERIA AND PERFORMANCE REPORT

OPEN TUBE PIEZOMETER DATA
PIEZOMETERS P-13 AND P-14


6300
6270
6240
6210
6180
6150
6120
6090
6060
6030
J F M A M J J A S O N D
1973
1974
1975
1976
POOL
P-13
P-14
P-15
P-18
1979
1980
1981
1982
P-13 is offset approximately 150 ft. from P-14
POOL
P-13 6042.00
P-14 6042.20
P-15 6042.00
P-18 6042.00







		MID TIP	TOP OF RISER
——	POOL		
—·—	P-13	6042 80	6373 74
– – –	P-14	6042 20	6364 60
━━	P-15	6042 00	6388 63
—··—	P-18	6042 00	6342 36

US ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
TULSA, OKLAHOMA

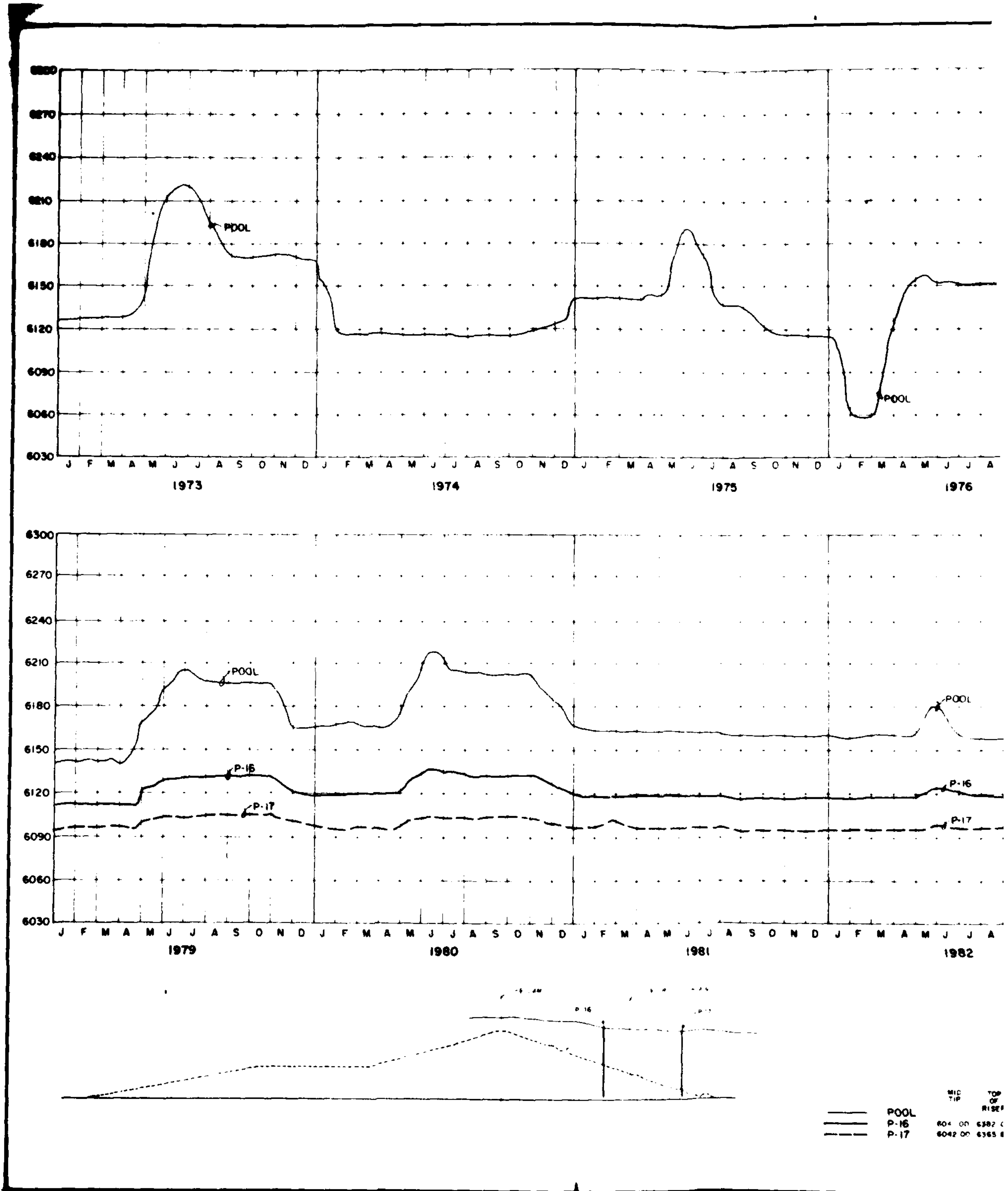
US ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ALBUQUERQUE, NEW MEXICO

ABIQUIU DAM

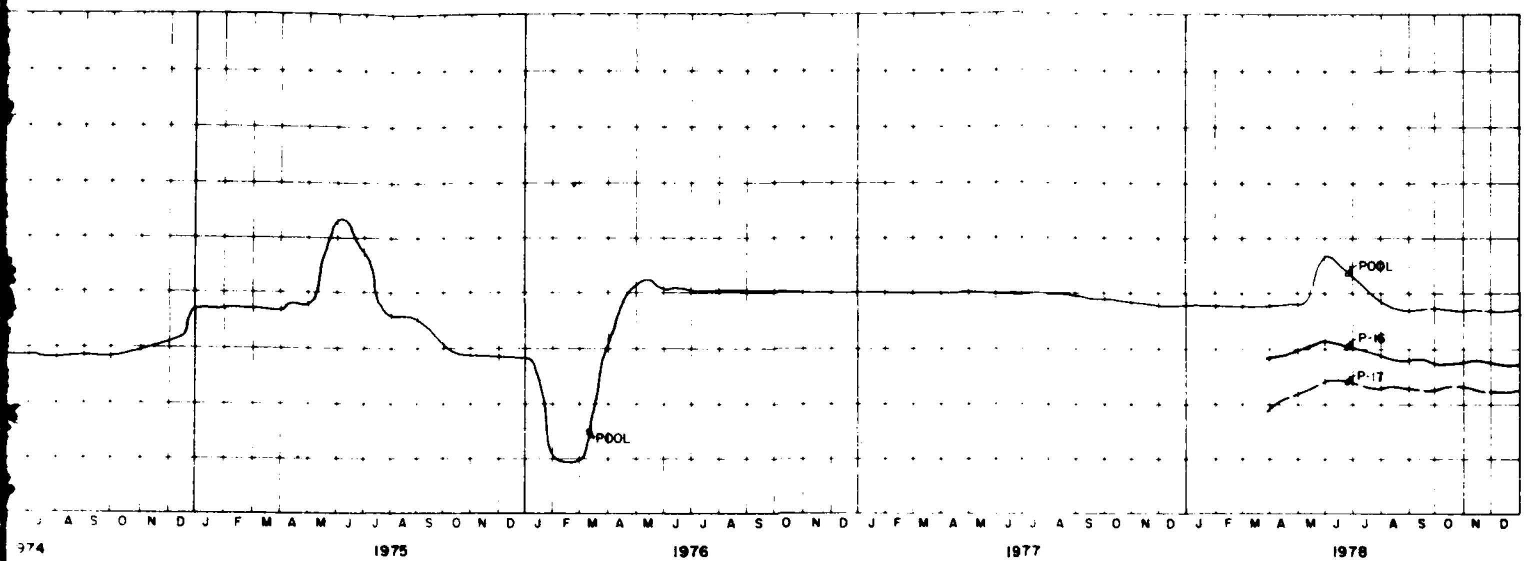
RIO GRANDE WATERSHED, RIO CHAMA
RIO ARRIBA COUNTY NEW MEXICO

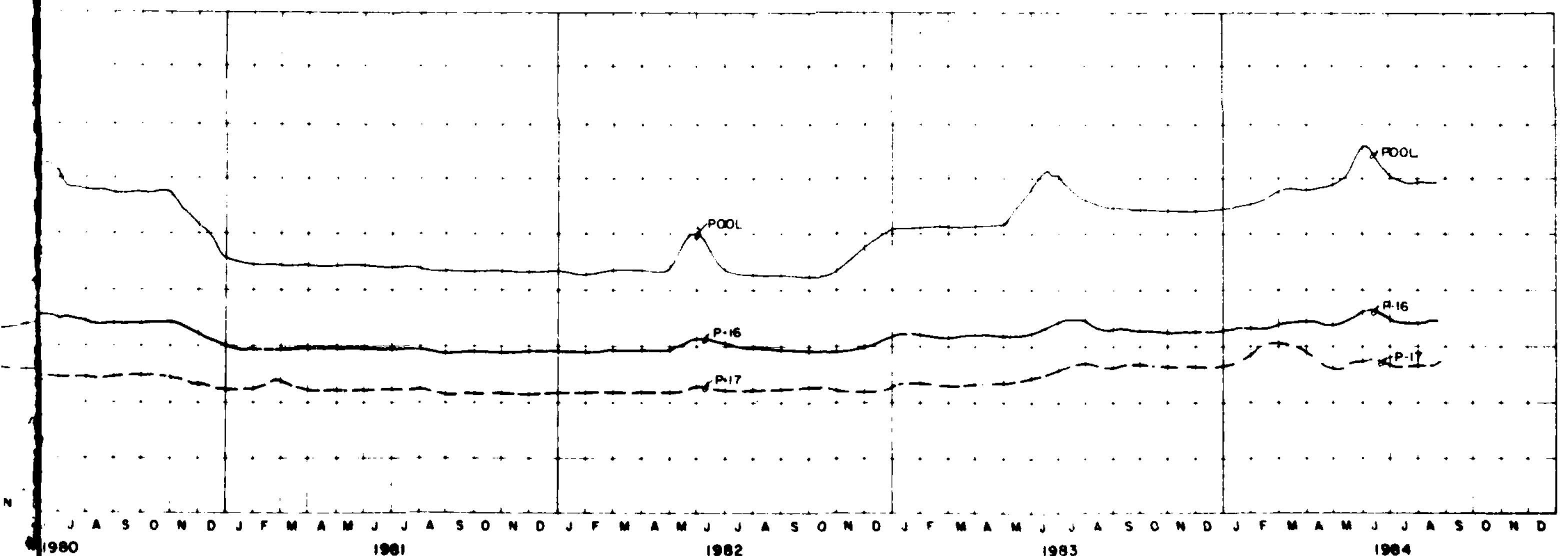
EMBANKMENT CRITERIA AND PERFORMANCE REPORT

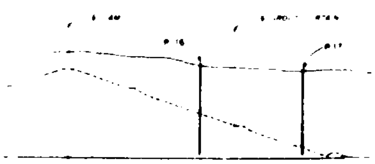
OPEN TUBE PIEZOMETER DATA
PIEZOMETERS P-13, P-14, P-15 & P-18



6300
6270
6240
6210
6180
6150
6120
6090
6060
6030
J F M A M J J A S O N D
1973
1974
1975
1976
POOL
1979
1980
1981
1982
P-16
P-17
POOL
P-16
P-17







		TIP	TOP OF RISER
———	POOL		
———	P-16	6042.00	6382.04
— — - —	P-17	6042.00	6365.80

US ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
TULSA, OKLAHOMA

US ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ALBUQUERQUE, NEW MEXICO

ABIQUIU DAM

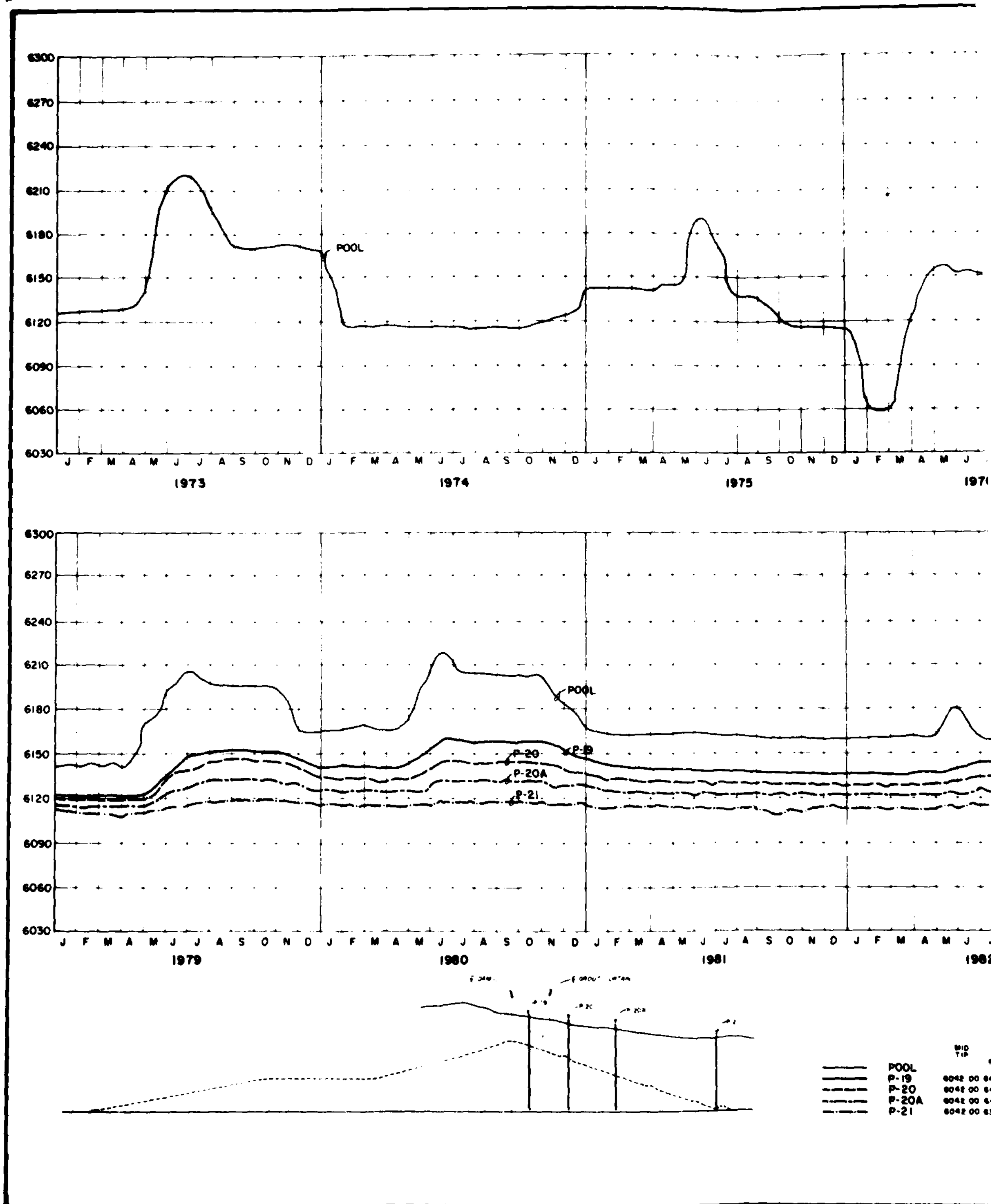
RIO GRANDE WATERSHED, RIO CHAMA
RIO ARRIBA COUNTY, NEW MEXICO

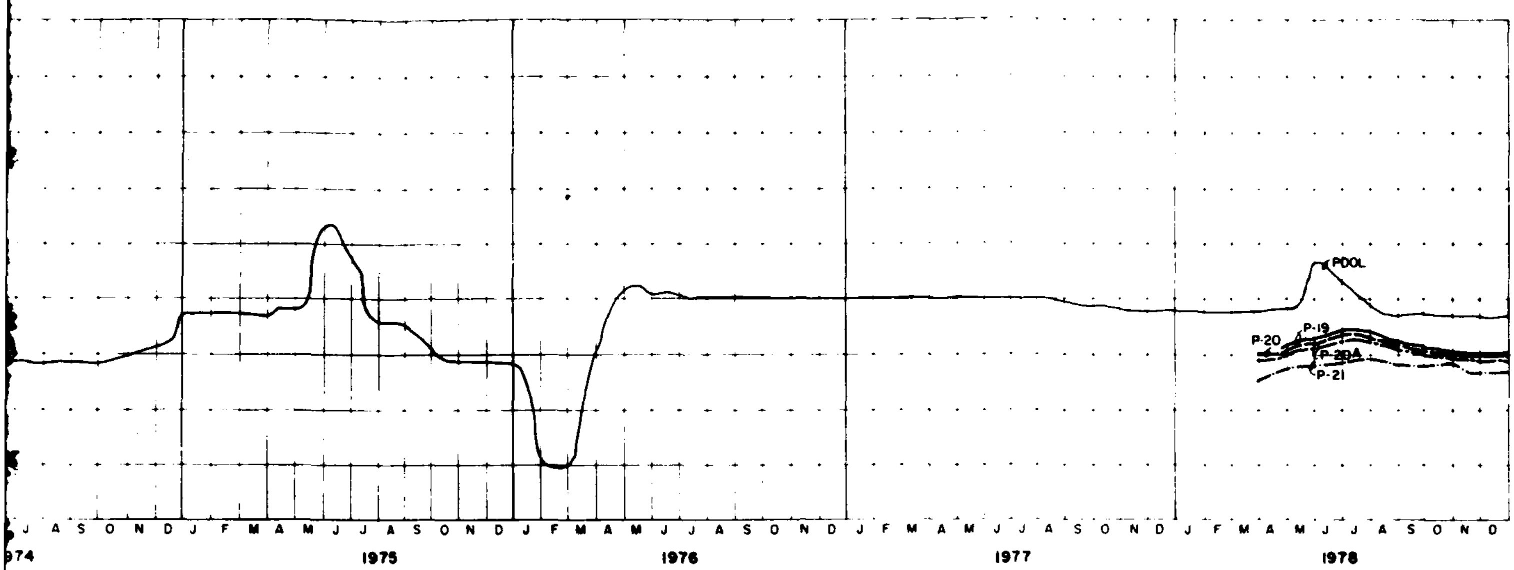
EMBANKMENT CRITERIA AND PERFORMANCE REPORT

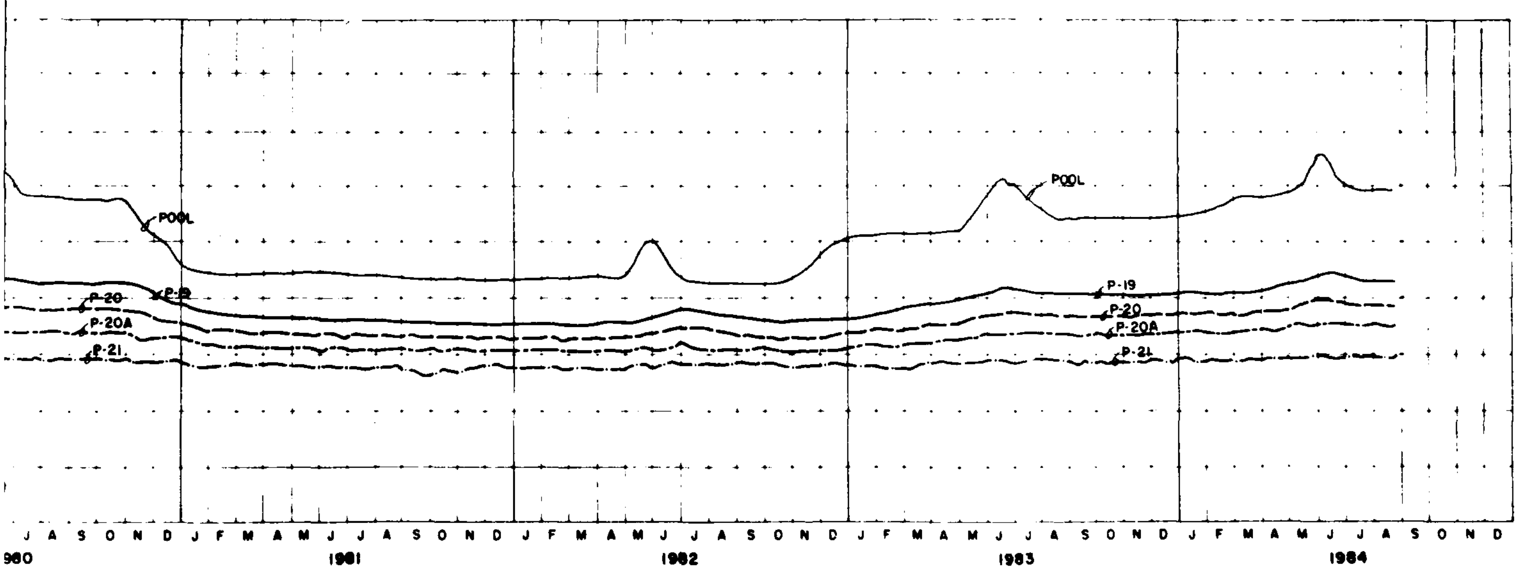
OPEN TUBE PIEZOMETER DATA

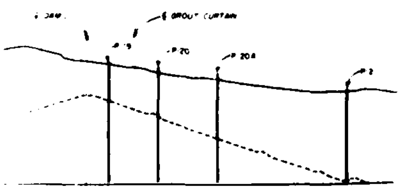
PIEZOMETERS P-16 AND P-17

2


6300
6270
6240
6210
6180
6150
6120
6090
6060
6030
POOL
J F M A M J J A S O N D
1973
1974
1975
1979
1980
1981
P-19
P-20
P-20A
P-21
POOL
P-19
P-20
P-20A
P-21







		MID TIP	TOP OF RISER
————	POOL		
————	P-19	6042 00	6482 38
— — — —	P-20	6042 00	6462 14
—·—·—	P-20A	6042 00	6445 39
—·—·—	P-21	6042 00	6386 86

US ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
TULSA, OKLAHOMA

US ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ALBUQUERQUE, NEW MEXICO

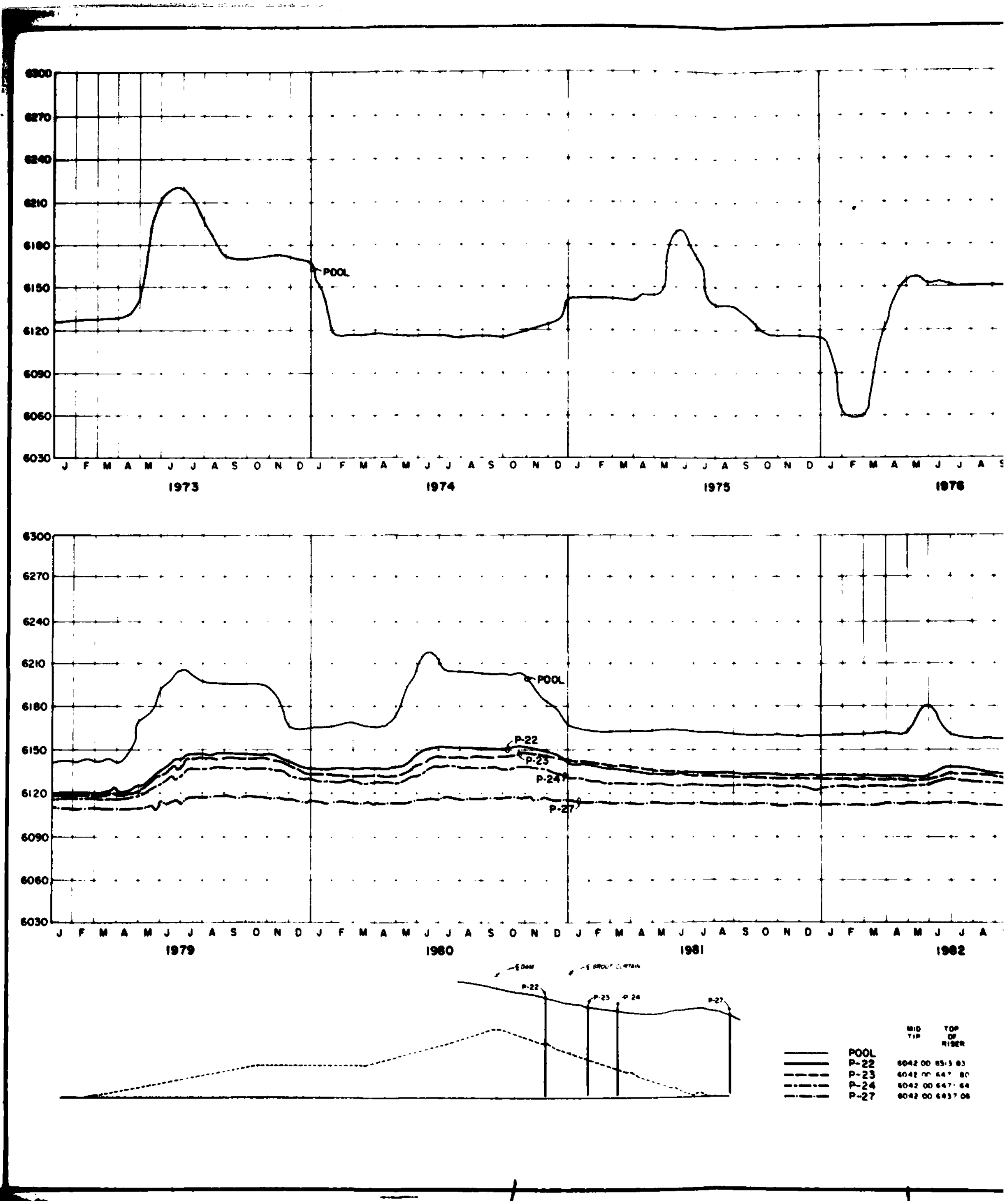
ABIQUIU DAM

RIO GRANDE WATERSHED, RIO CHAMA
RIO ARRIBA COUNTY, NEW MEXICO

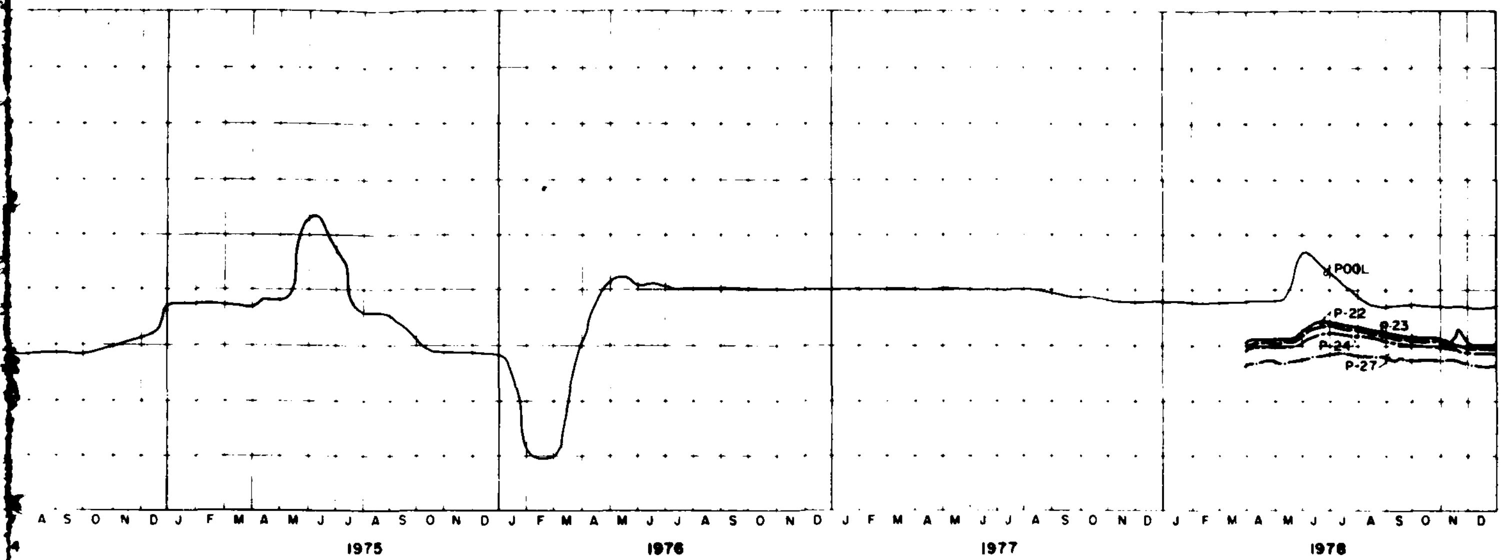
EMBANKMENT CRITERIA AND PERFORMANCE REPORT

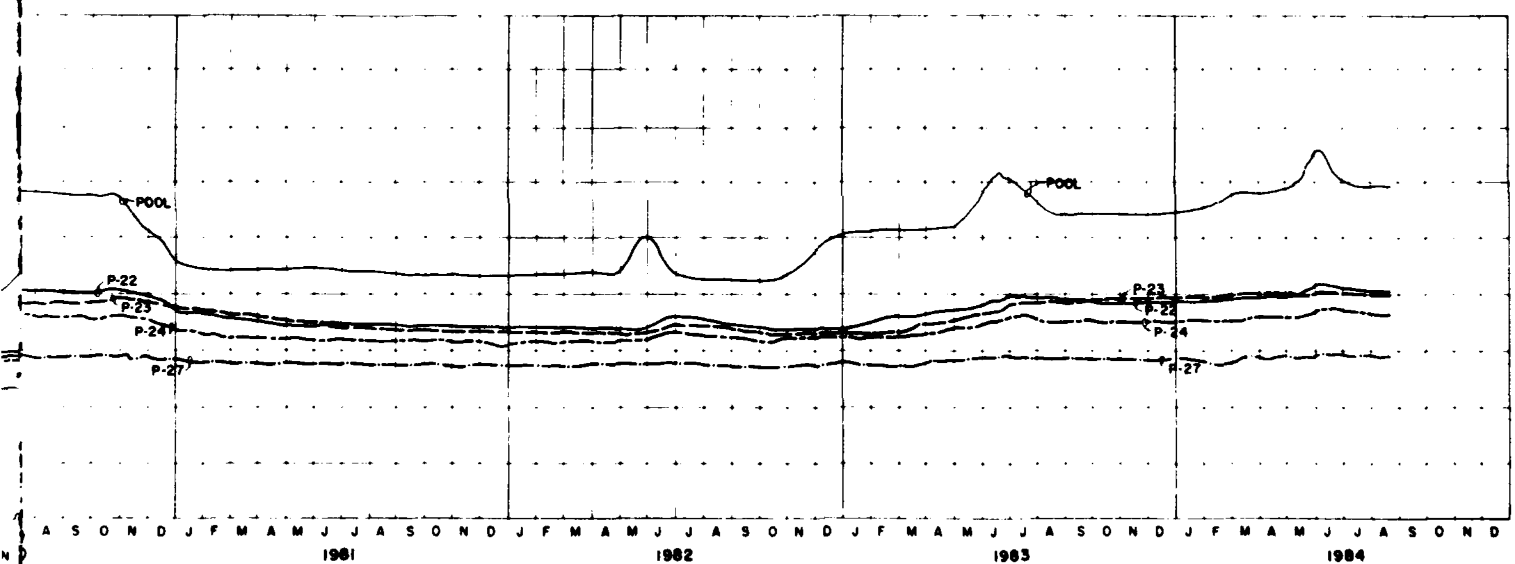
OPEN TUBE PIEZOMETER DATA

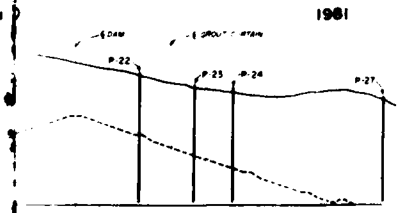
PIEZOMETERS P-19, P-20, P-20A, P-21



6300
6270
6240
6210
6180
6150
6120
6090
6060
6030
J F M A M J J A S O N D
1973
1974
1975
1976
POOL
1979
1980
1981
1982
P-22
P-23
P-24
P-27
MID TIP
TOP OF RISER
POOL
P-22 6042.00
P-23
P-24 6042.00
P-27 6042.00







		MID TIP	TOP OF RISER
——	POOL		
——	P-22	6042.00	6513.83
– – –	P-23	6042.00	64?.80
–·–·–	P-24	6042.00	647.64
–··–··–	P-27	6042.00	6437.06

US ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
TULSA, OKLAHOMA

US ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ALBUQUERQUE, NEW MEXICO

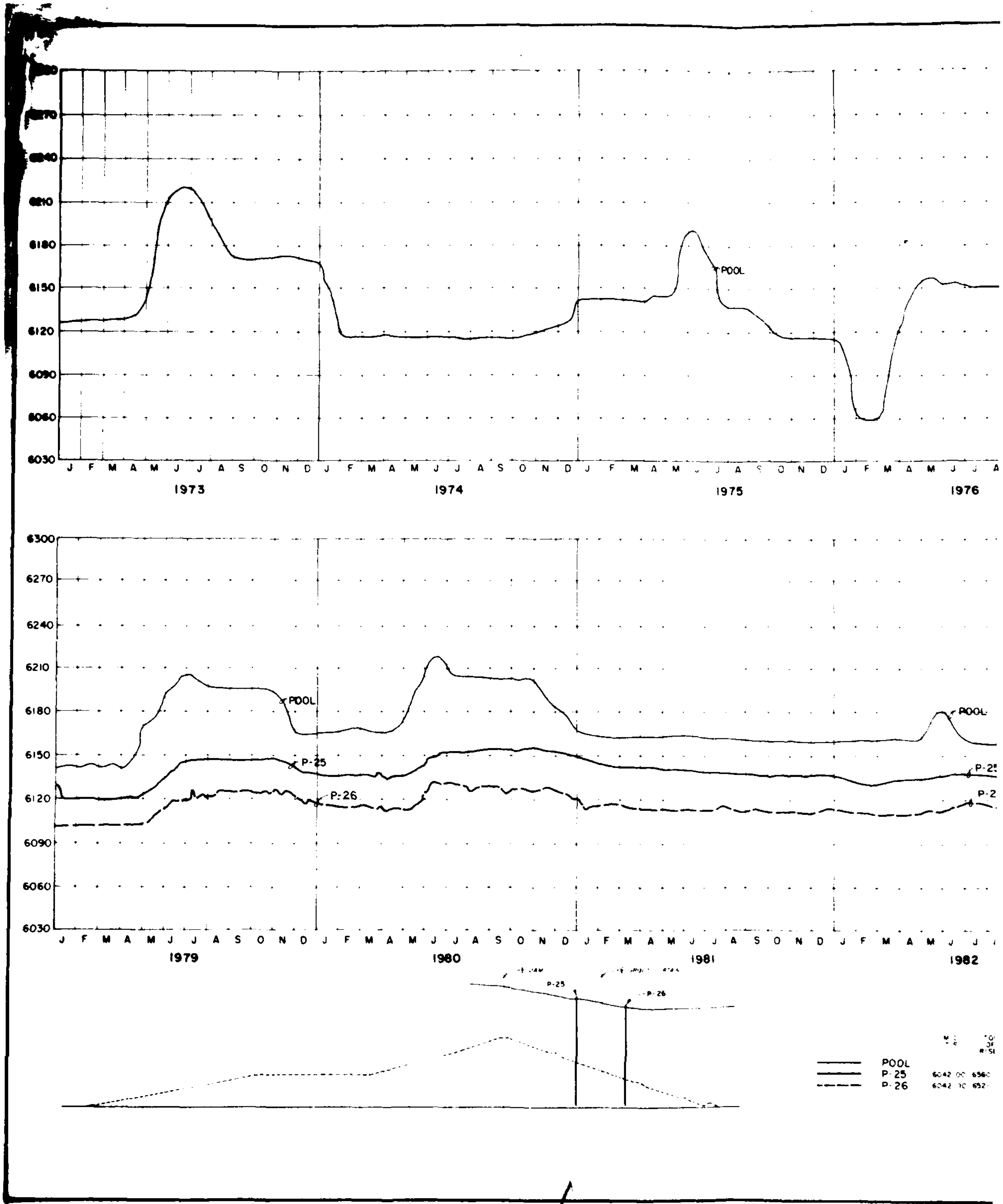
ABIQUIU DAM

RIO GRANDE WATERSHED, RIO CHAMA
RIO ARRIBA COUNTY, NEW MEXICO

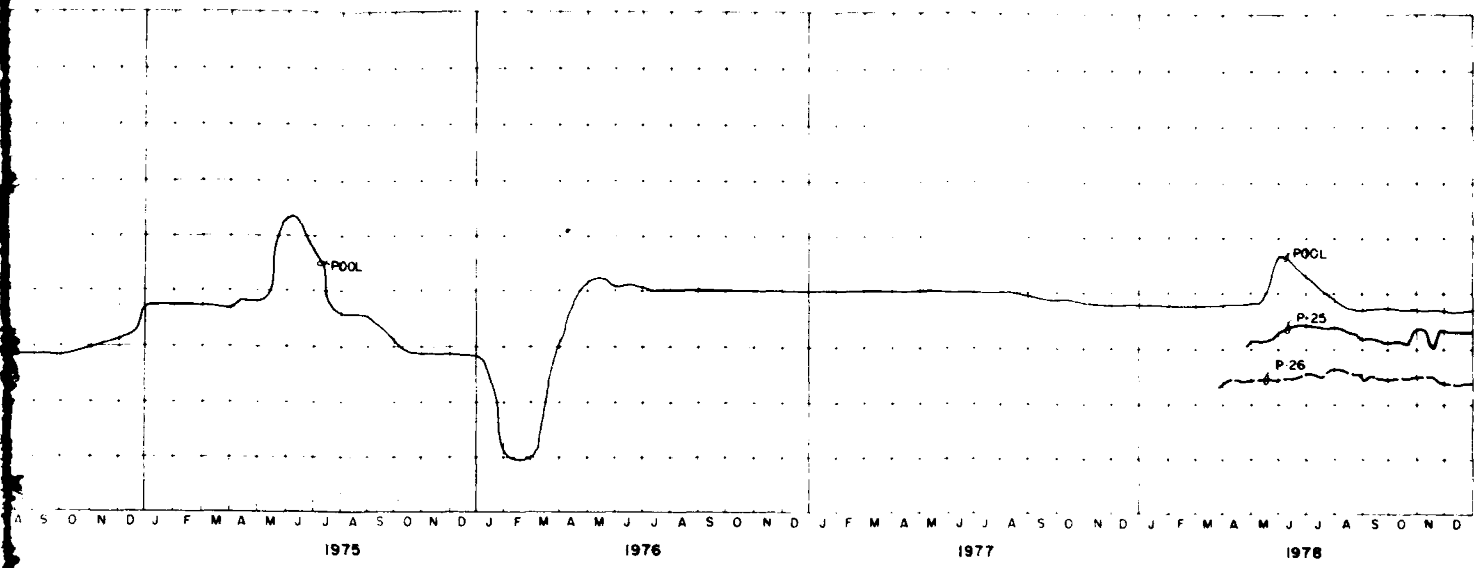
EMBANKMENT CRITERIA AND PERFORMANCE REPORT

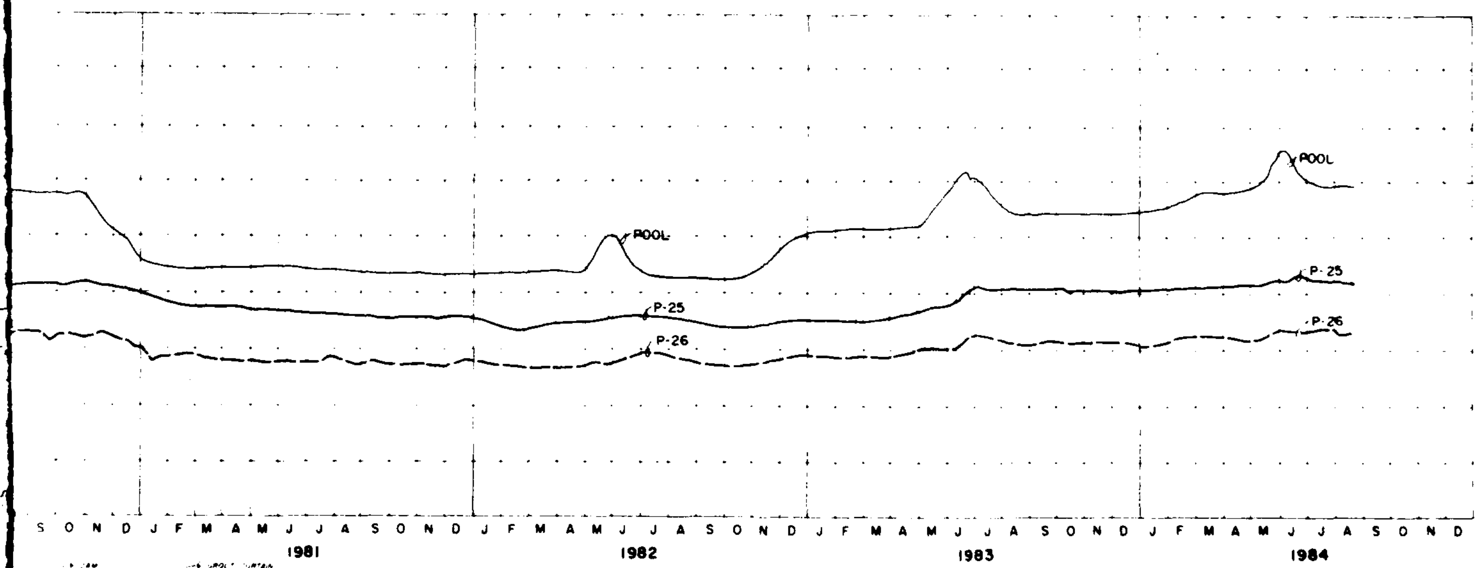
OPEN TUBE PIEZOMETER DATA

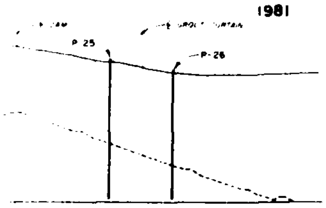
PIEZOMETERS P-22, P-23, P-24 & P-27



6300
6270
6240
6210
6180
6150
6120
6090
6060
6030
POOL
J F M A M J J A S O N D
1973
1974
1975
1976
P-25
P-26
1979
1980
1981
1982
POOL
P-25
P-26







		MID TIP	TOP OF RISER
———	POOL		
———	P-25	6042 00	6560 43
– – – –	P-26	6042 00	6521 84

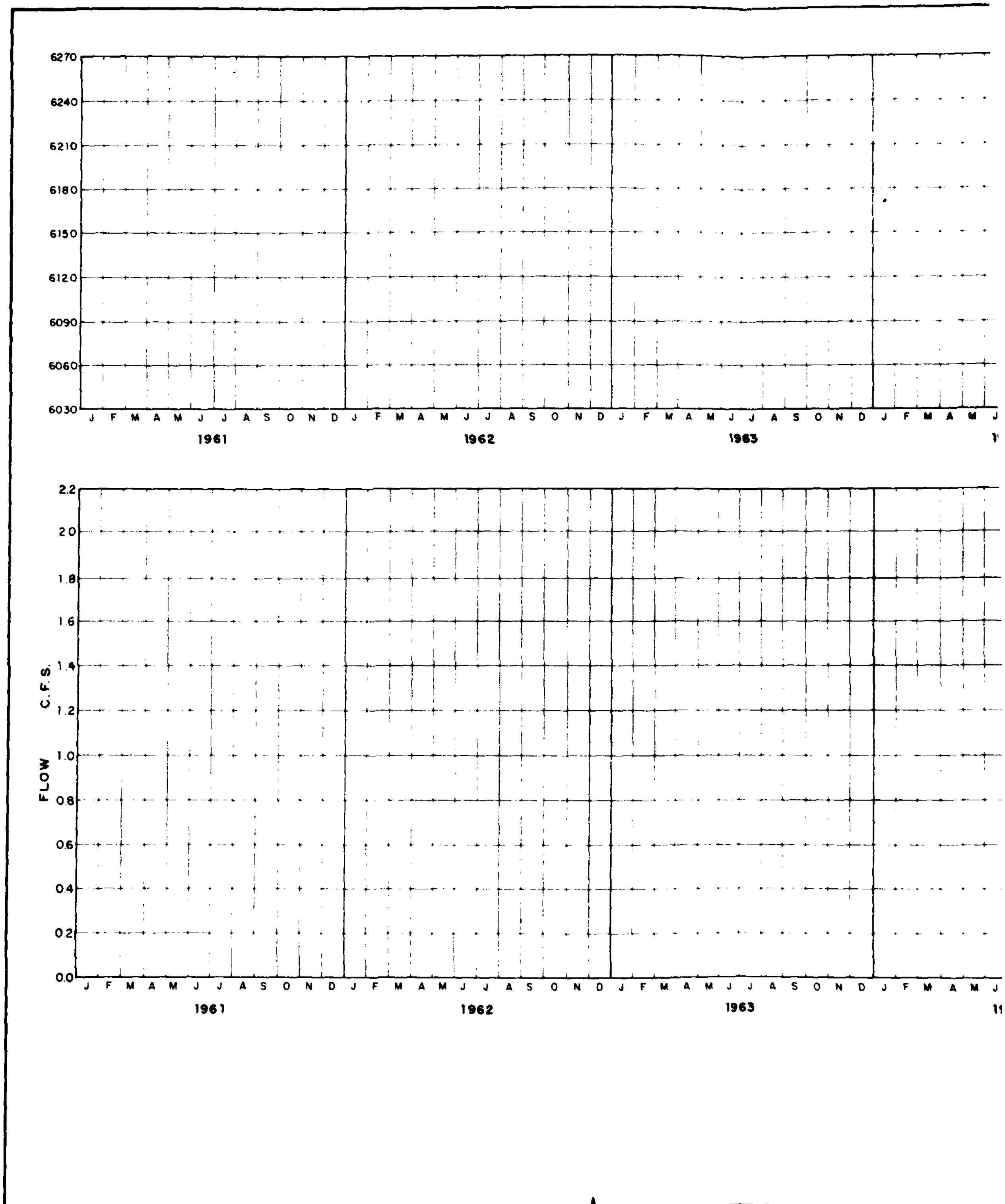
US ARMY ENGINEER DISTRICT CORPS OF ENGINEERS TULSA, OKLAHOMA	US ARMY ENGINEER DISTRICT CORPS OF ENGINEERS ALBUQUERQUE, NEW MEXICO

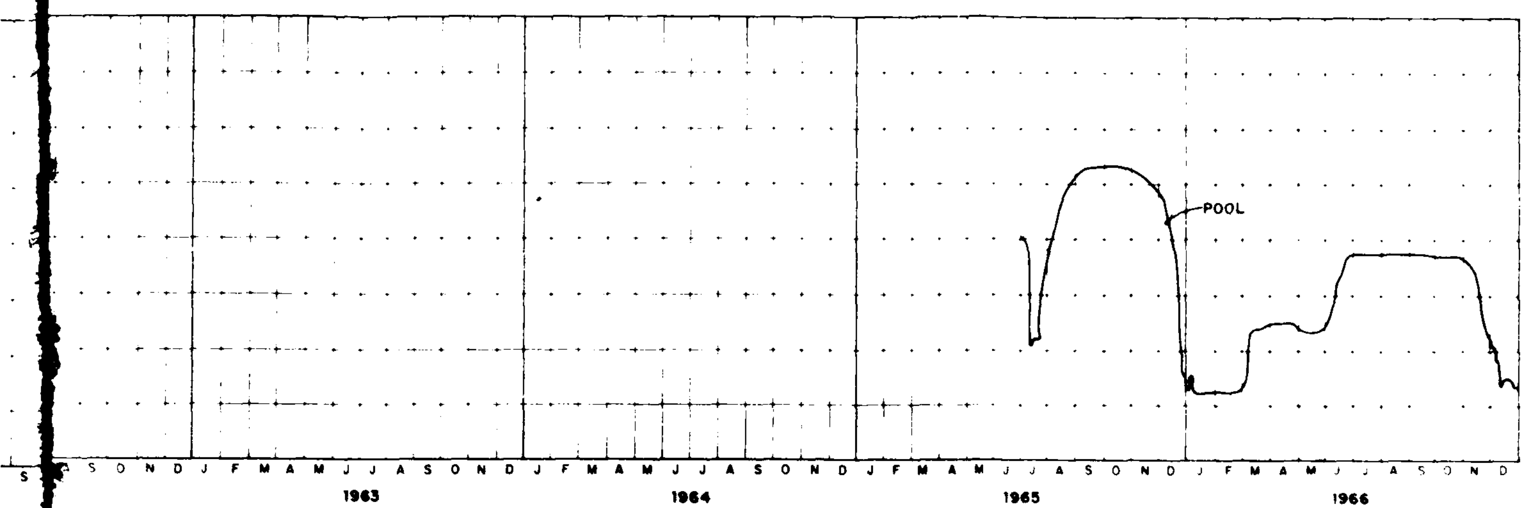
ABIQUIU DAM

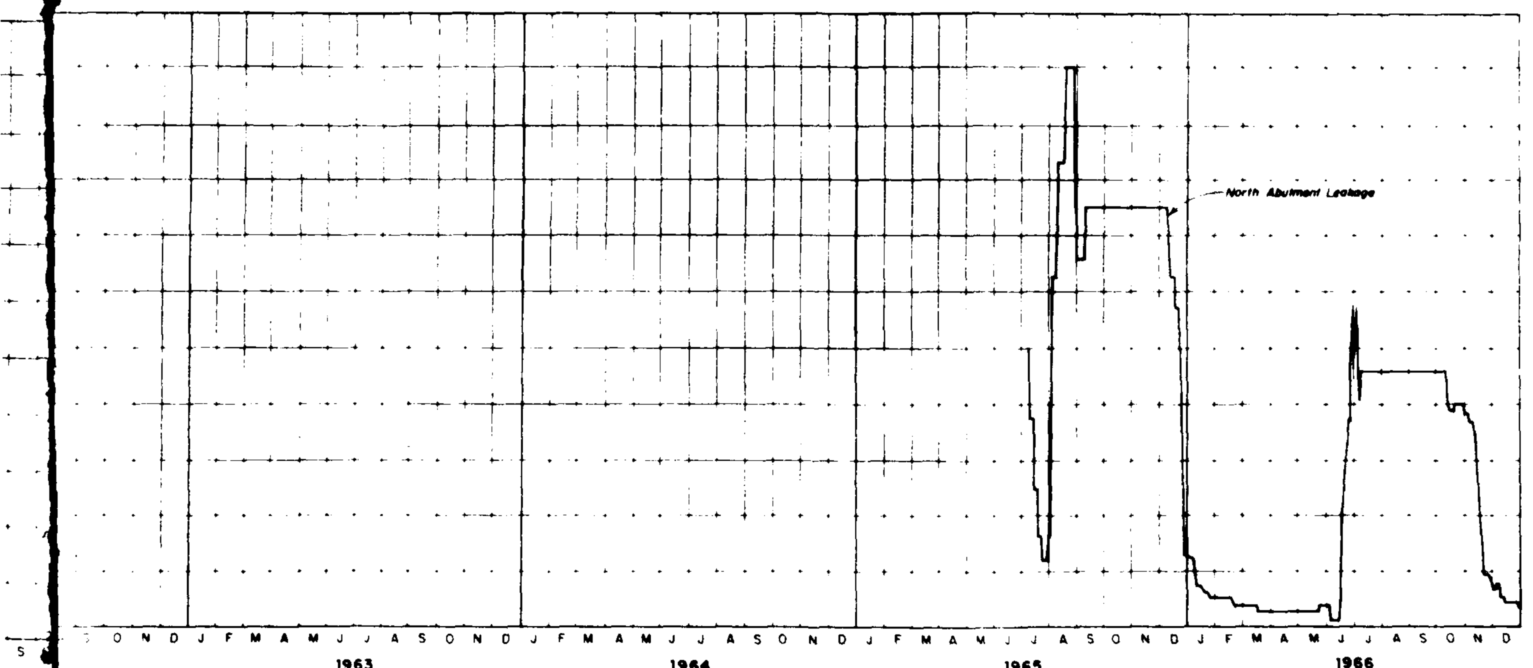
RIO GRANDE WATERSHED, RIO CHAMA
RIO ARRIBA COUNTY, NEW MEXICO

EMBANKMENT CRITERIA AND PERFORMANCE REPORT

OPEN TUBE PIEZOMETER DATA
PIEZOMETERS P-25 AND P-26


6270
6240
6210
6180
6150
6120
6090
6060
6030
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J
1961
1962
1963
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
FLOW C.F.S.
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J
1961
1962
1963





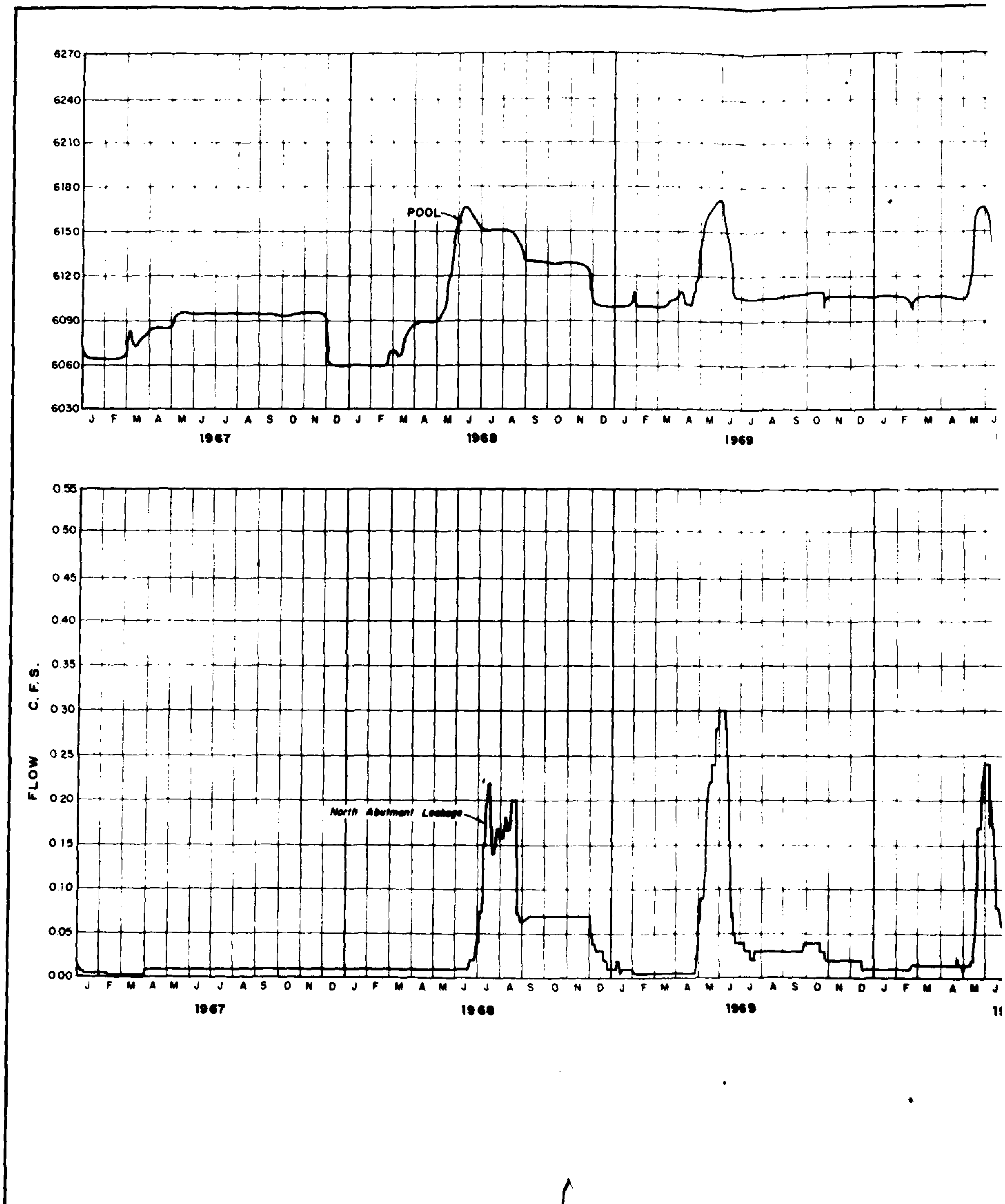
U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS TULSA, OKLAHOMA	U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS ALBUQUERQUE, NEW MEXICO

ABIQUIU DAM

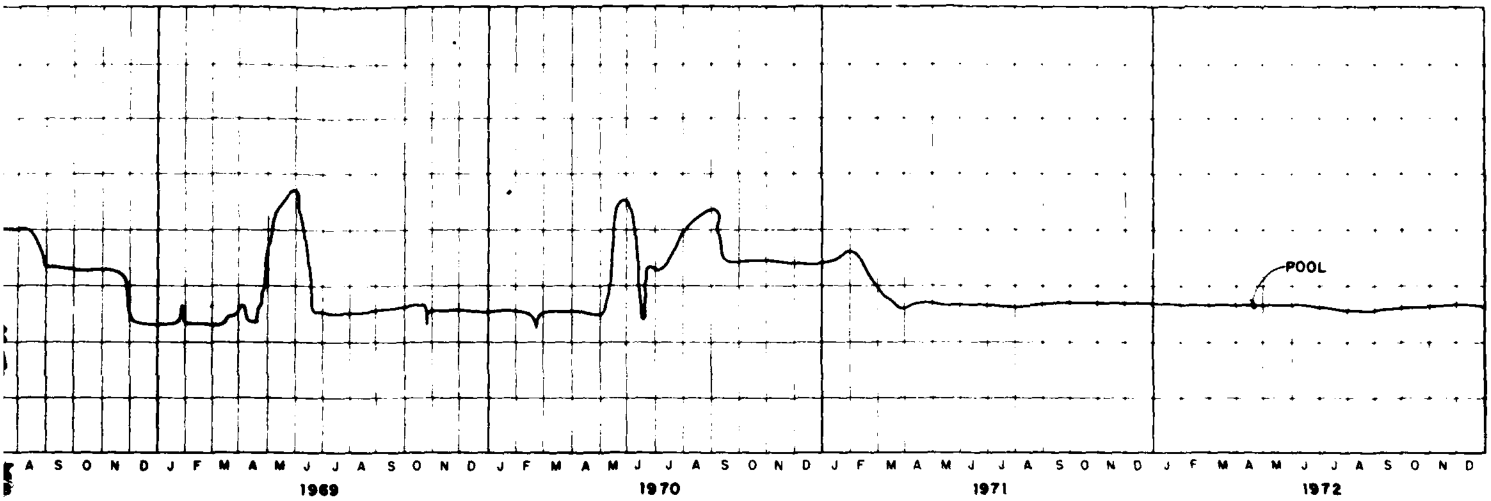
RIO GRANDE WATERSHED, RIO CHAMA
RIO ARRIBA COUNTY, NEW MEXICO

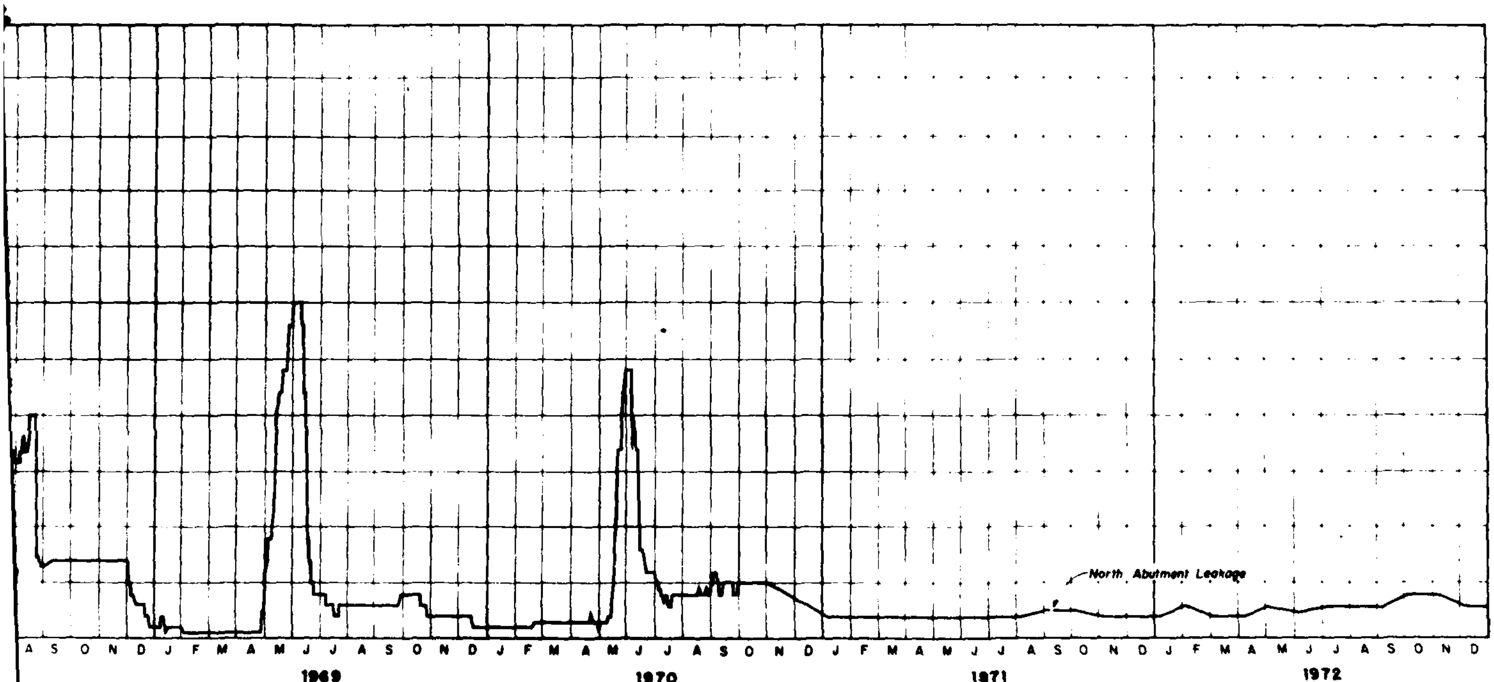
EMBANKMENT CRITERIA AND PERFORMANCE REPORT

ABUTMENT LEAKAGE
NORTH ABUTMENT LEAKAGE FLOW



6270
6240
6210
6180
6150
6120
6090
6060
6030
POOL
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J
1967
1968
1969
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
FLOW C.F.S.
North Abutment Leakage
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J
1967
1968
1969





U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS TULSA, OKLAHOMA	U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS ALBUQUERQUE, NEW MEXICO

ABIQUIU DAM

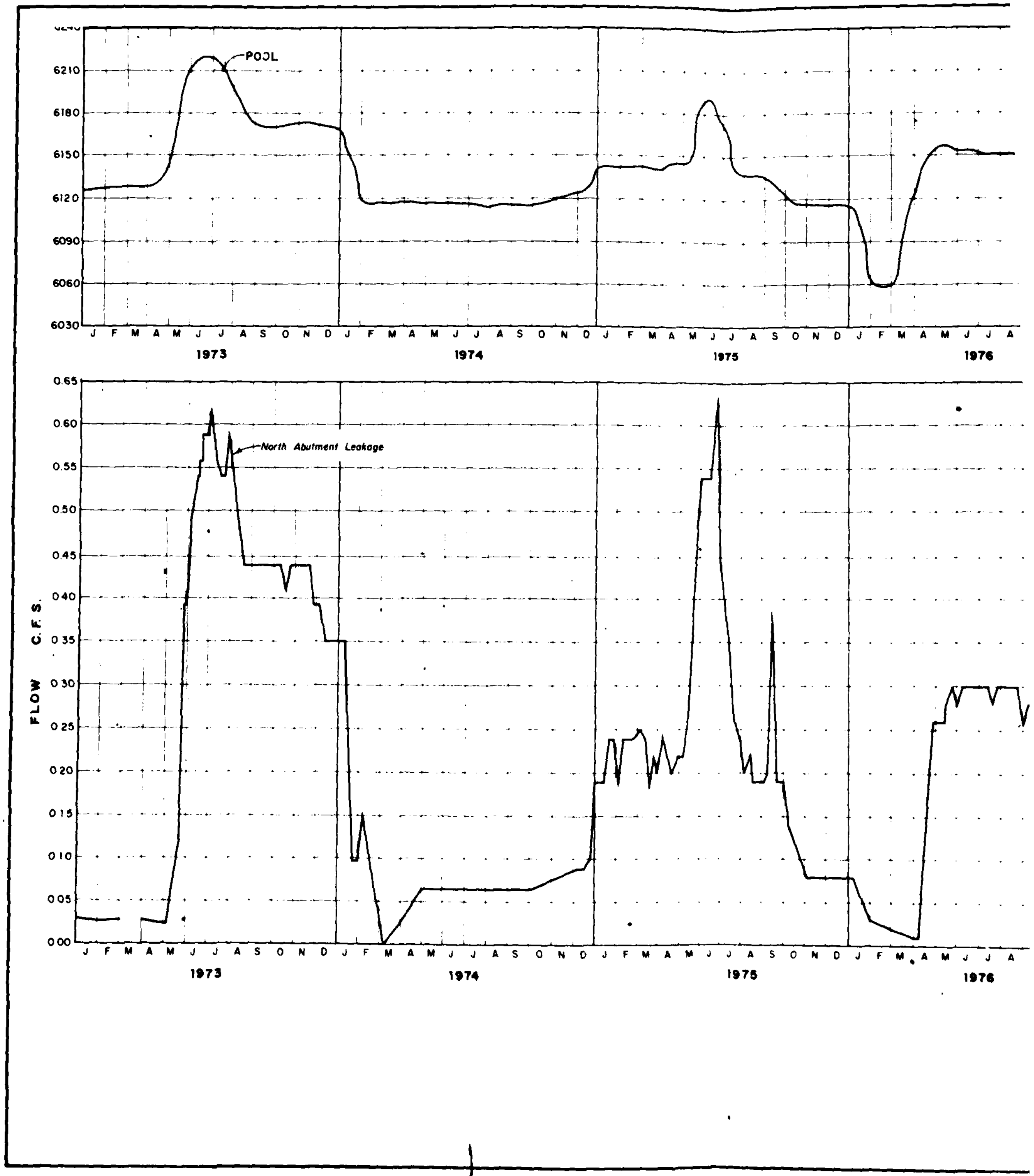
RIO GRANDE WATERSHED, RIO CHAMA
RIO ARRIBA COUNTY, NEW MEXICO

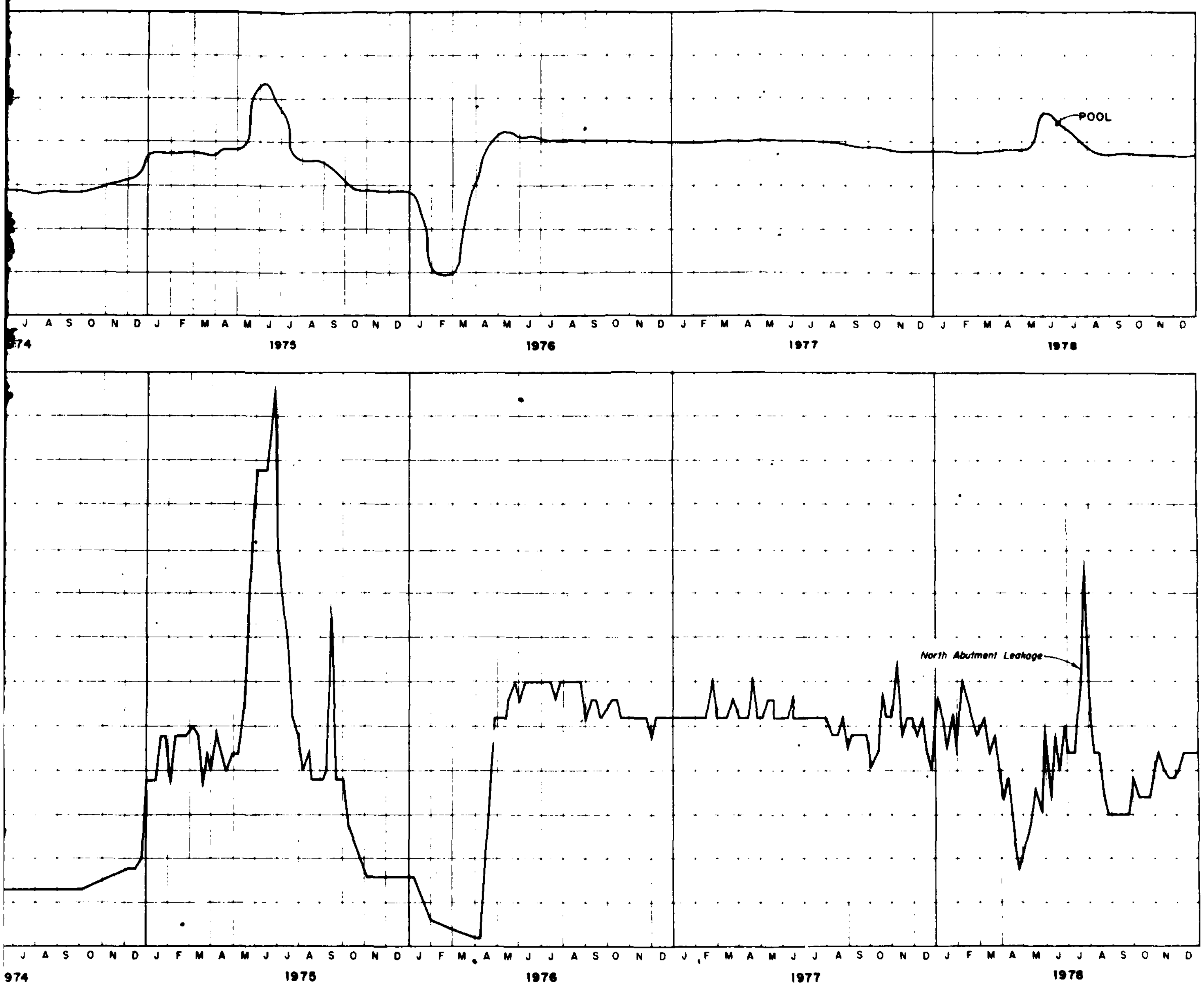
EMBANKMENT CRITERIA AND PERFORMANCE REPORT

ABUTMENT LEAKAGE

NORTH ABUTMENT LEAKAGE FLOW

2


POOL
6240
6210
6180
6150
6120
6090
6060
6030
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A
1973
1974
1975
1976
North Abutment Leakage
FLOW C.F.S.
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A
1973
1974
1975
1976



U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS TULSA, OKLAHOMA	U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS ALBUQUERQUE, NEW MEXICO

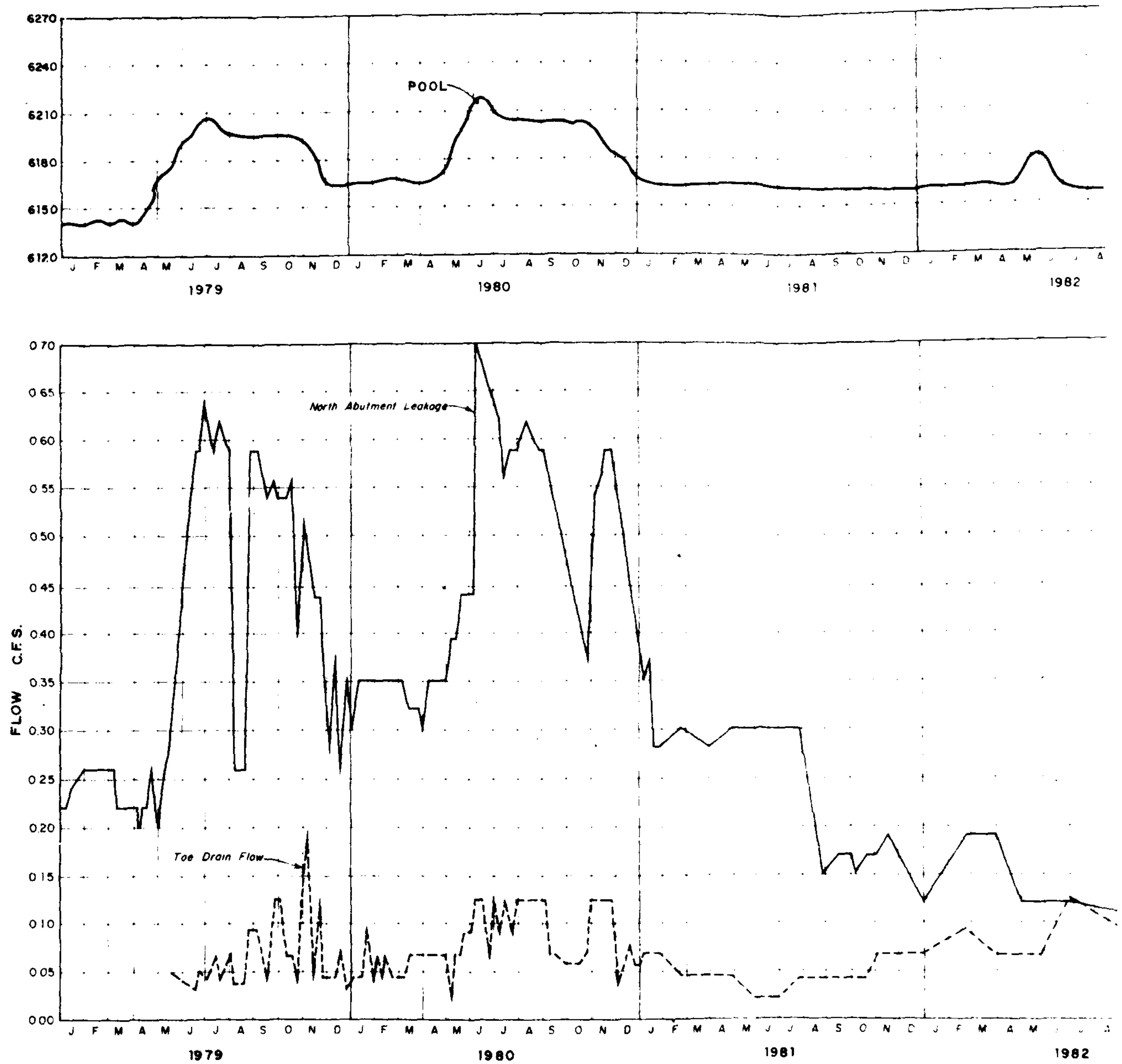
ABIQUIU DAM

RIO GRANDE WATERSHED, RIO CHAMA
RIO ARRIBA COUNTY, NEW MEXICO

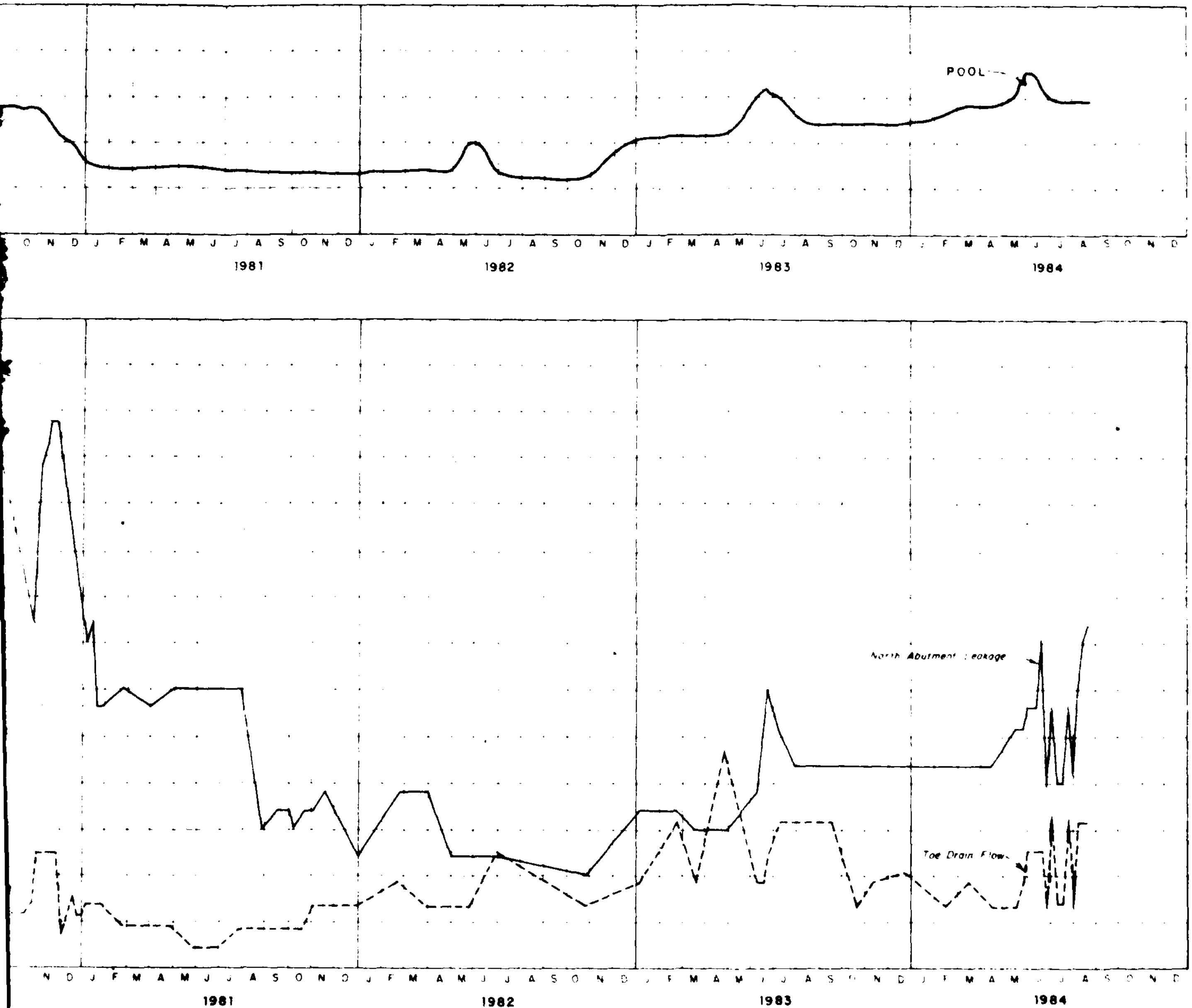
EMBANKMENT CRITERIA AND PERFORMANCE REPORT

ABUTMENT LEAKAGE

NORTH ABUTMENT LEAKAGE FLOW



6270
6240
6210
6180
6150
6120
POOL
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A
1979
1980
1981
1982
FLOW C.F.S.
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
North Abutment Leakage
Toe Drain Flow
1979
1980
1981
1982

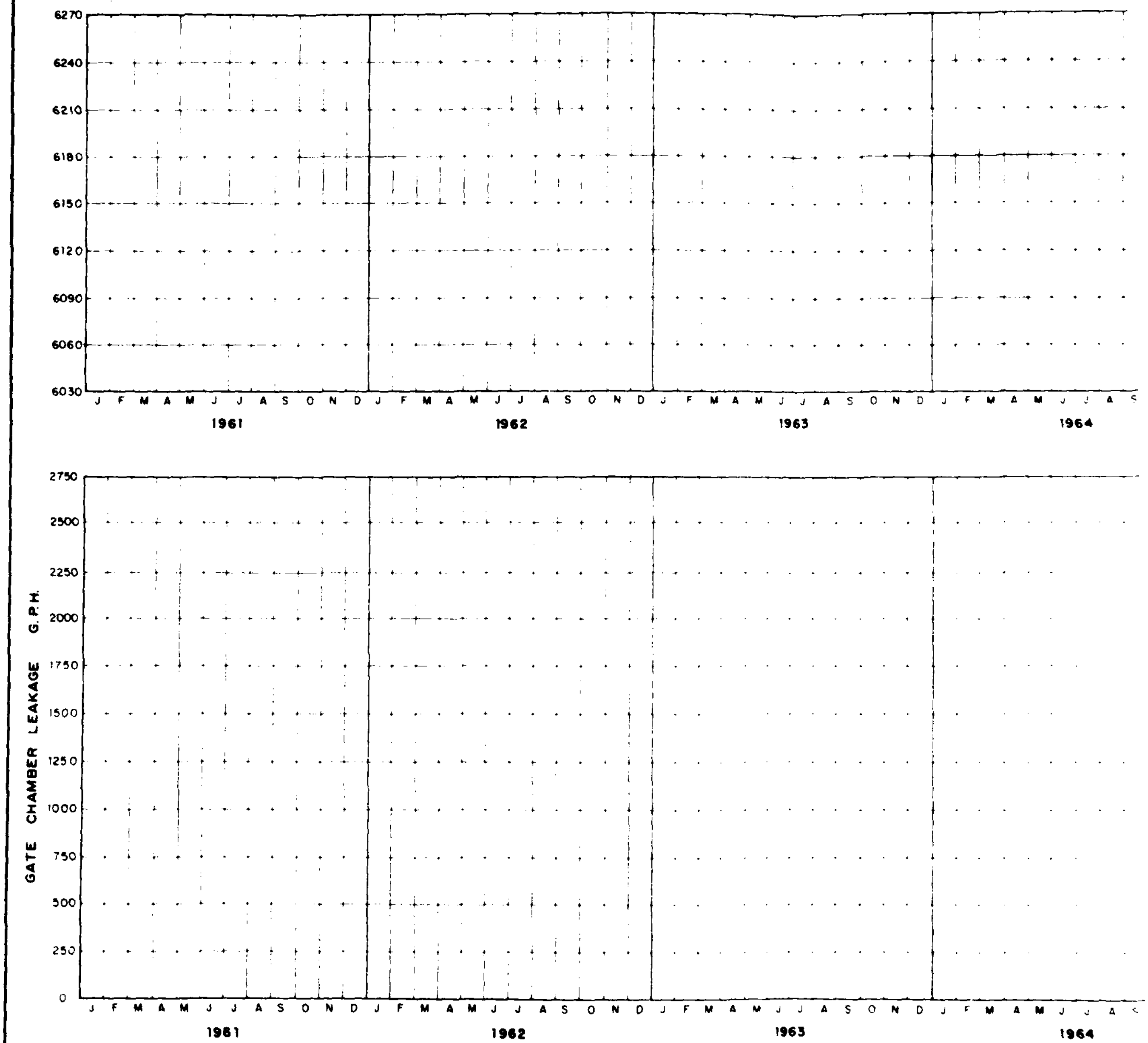


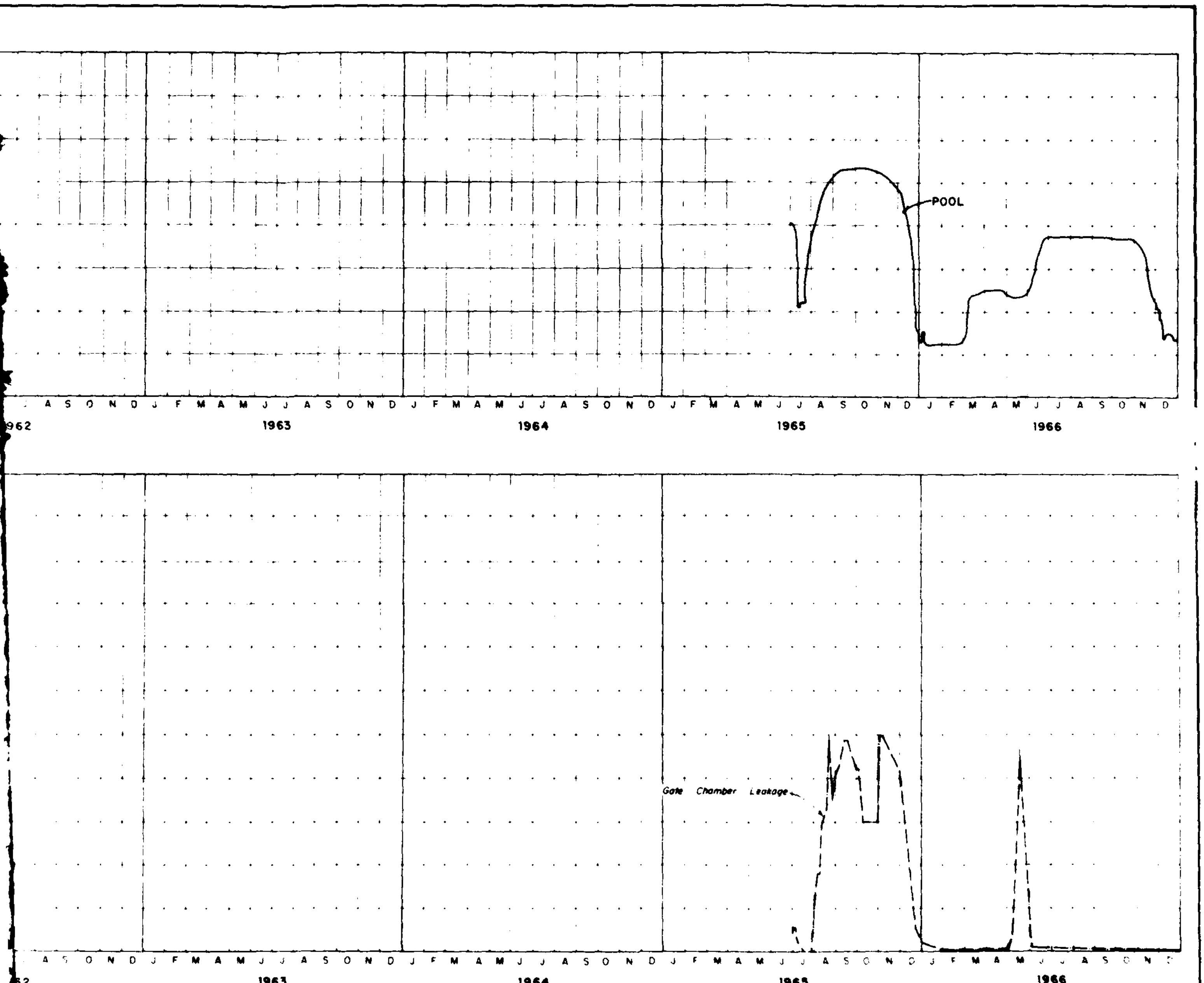
ABIQUIU DAM

EMBANKMENT CRITERIA AND PERFORMANCE REPORT

ABUTMENT LEAKAGE

NORTH ABUTMENT LEAKAGE FLOW AND TOE DRAIN FLOW


6270
6240
6210
6180
6150
6120
6090
6060
6030
J F M A M J J A S O N D
1961
1962
1963
1964
2750
2500
2250
2000
1750
1500
1250
1000
750
500
250
0
GATE CHAMBER LEAKAGE G.P.H.

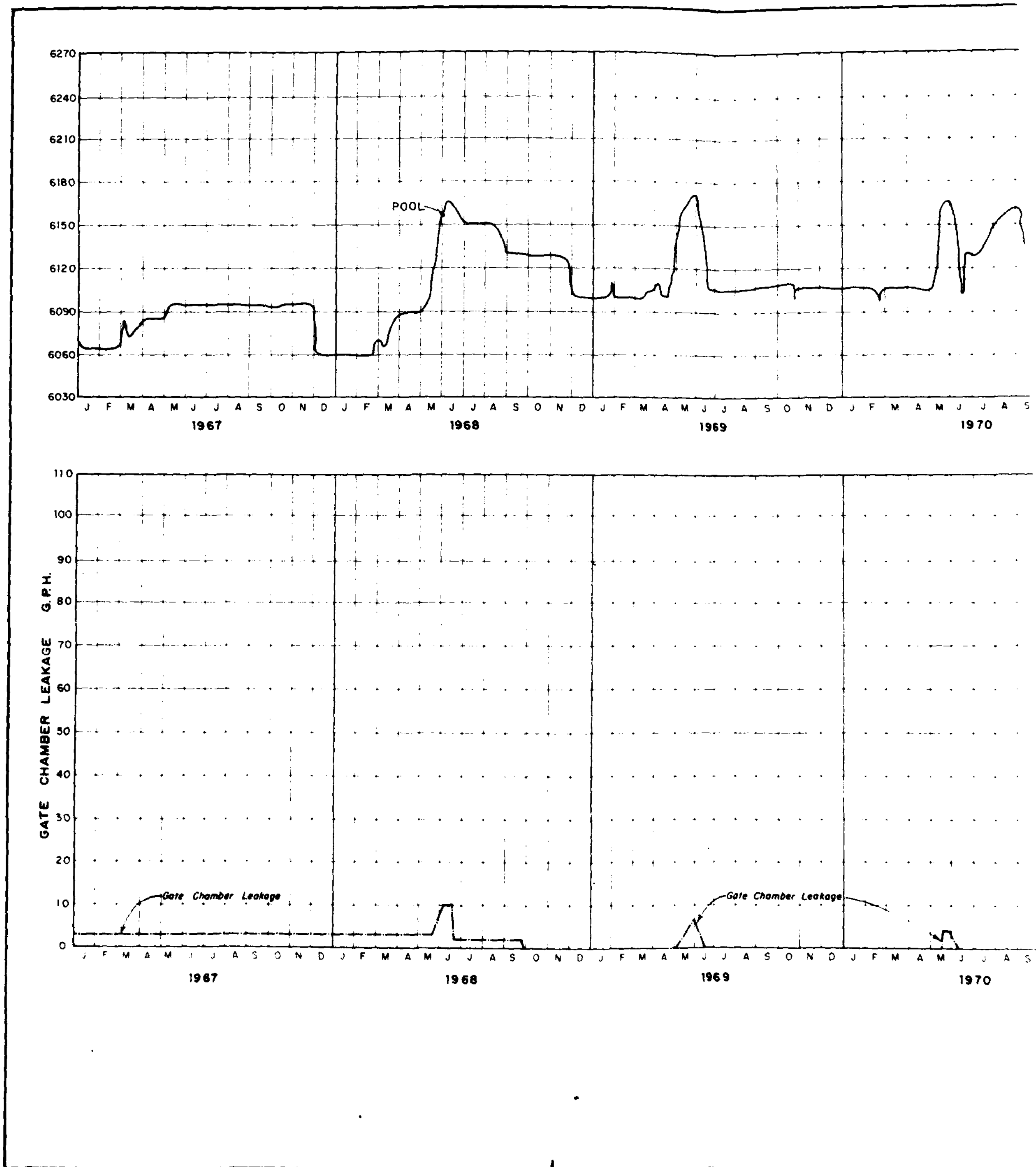


ABIQUIU DAM

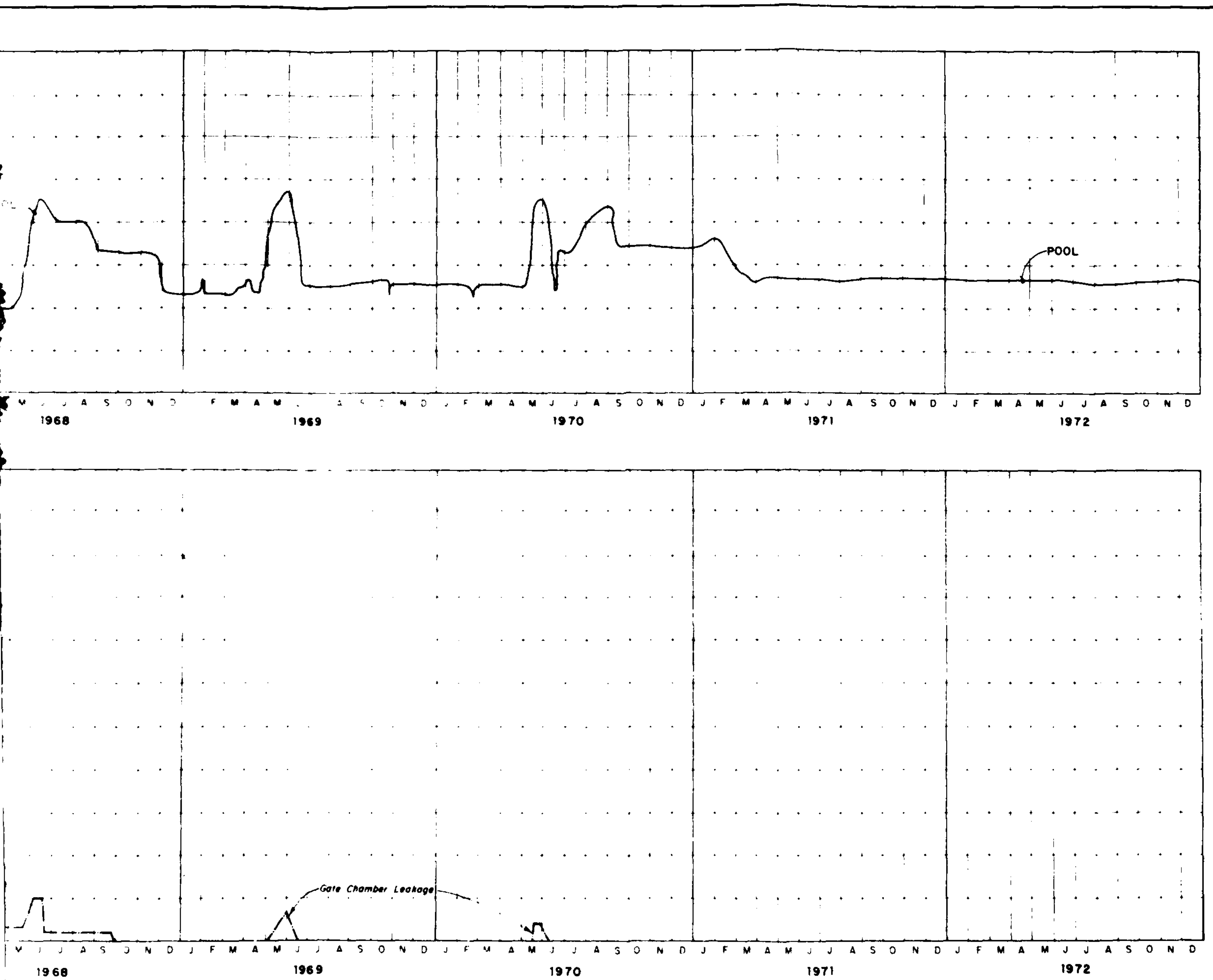
RIO GRANDE WATERSHED, R. CHAMA
RIO ARRIBA COUNTY, NEW MEXICO

EMBANKMENT CRITERIA AND PERFORMANCE REPORT

ABUTMENT LEAKAGE
GATE CHAMBER LEAKAGE FLOW



6270
6240
6210
6180
6150
6120
6090
6060
6030
POOL
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S
1967
1968
1969
1970
GATE CHAMBER LEAKAGE G.P.H.
110
100
90
80
70
60
50
40
30
20
10
0
Gate Chamber Leakage
Gate Chamber Leakage
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S
1967
1968
1969
1970



U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
TULSA, OKLAHOMA

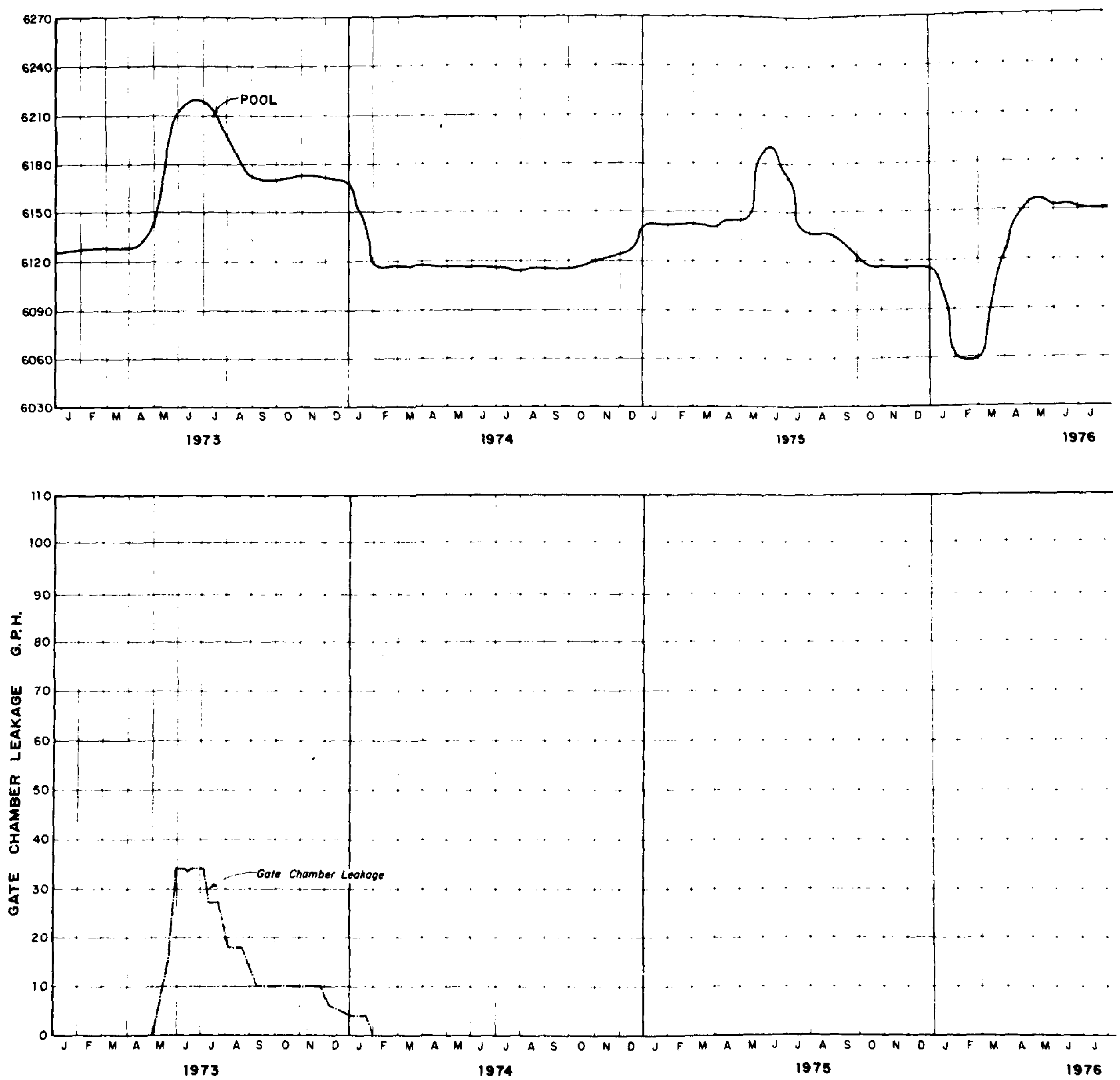
U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
ALBUQUERQUE, NEW MEXICO

ABIQUIU DAM

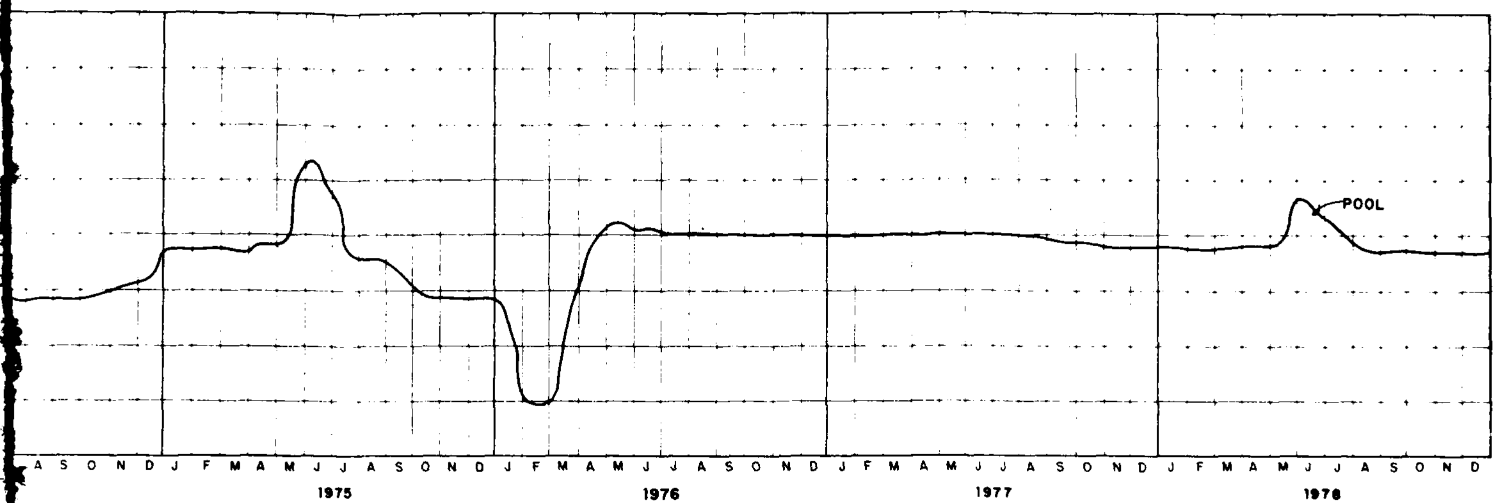
RIO GRANDE WATERSHED, RIO CHAMA
RIO ARRIBA COUNTY, NEW MEXICO

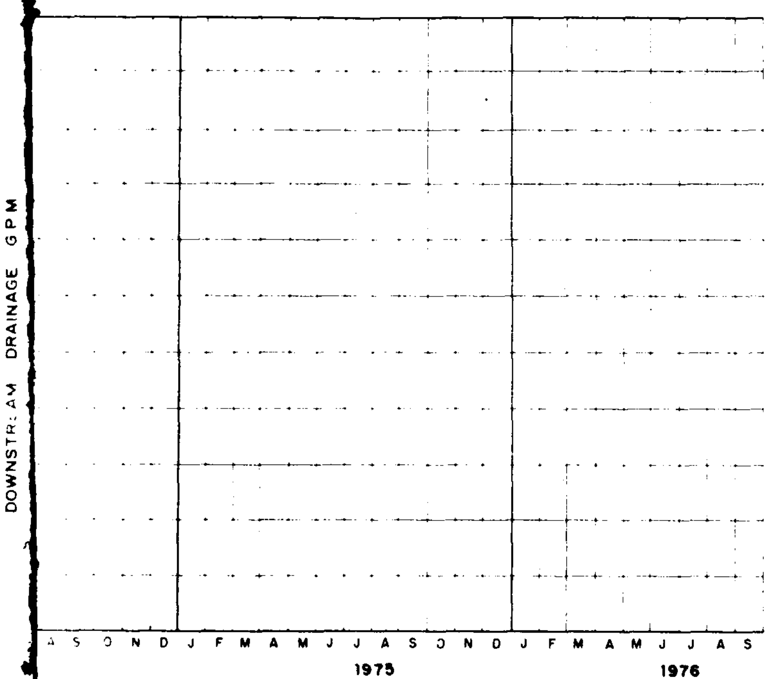
EMBANKMENT CRITERIA AND PERFORMANCE REPORT

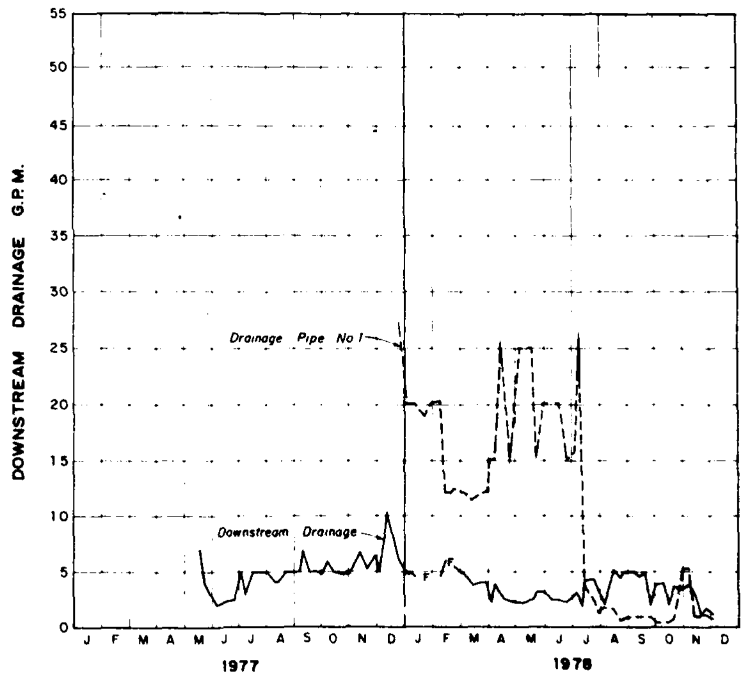
ABUTMENT LEAKAGE
GATE CHAMBER LEAKAGE FLOW



POOL
6270
6240
6210
6180
6150
6120
6090
6060
6030
J F M A M J J A S O N D
1973
1974
1975
1976
GATE CHAMBER LEAKAGE G.P.H.
Gate Chamber Leakage
110
100
90
80
70
60
50
40
30
20
10
0







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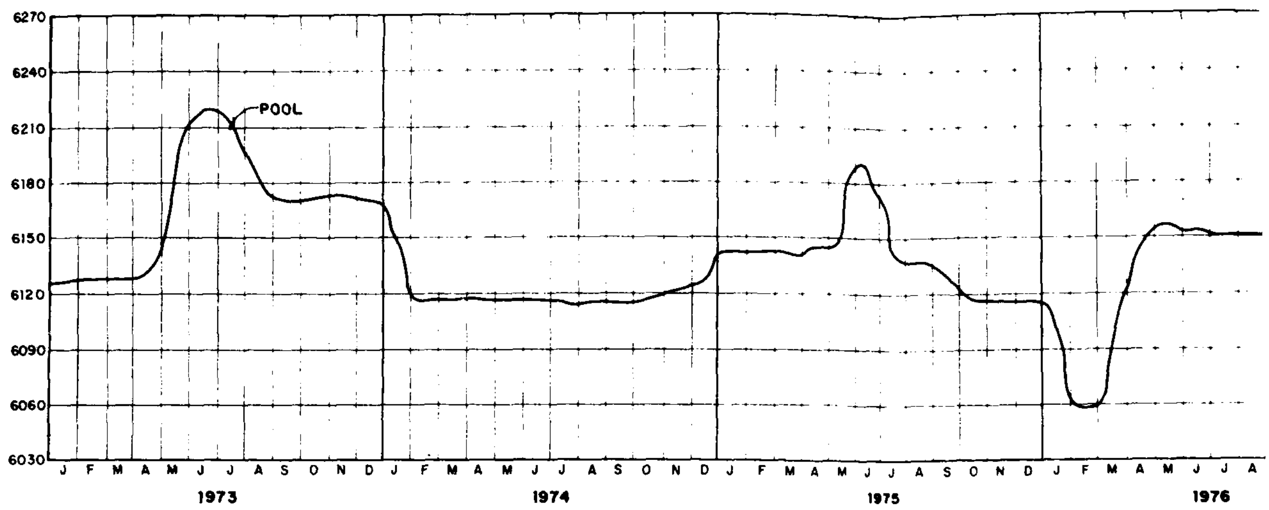
RIO GRANDE WATERSHED, RIO CHAMA
RIO ARRIBA COUNTY, NEW MEXICO

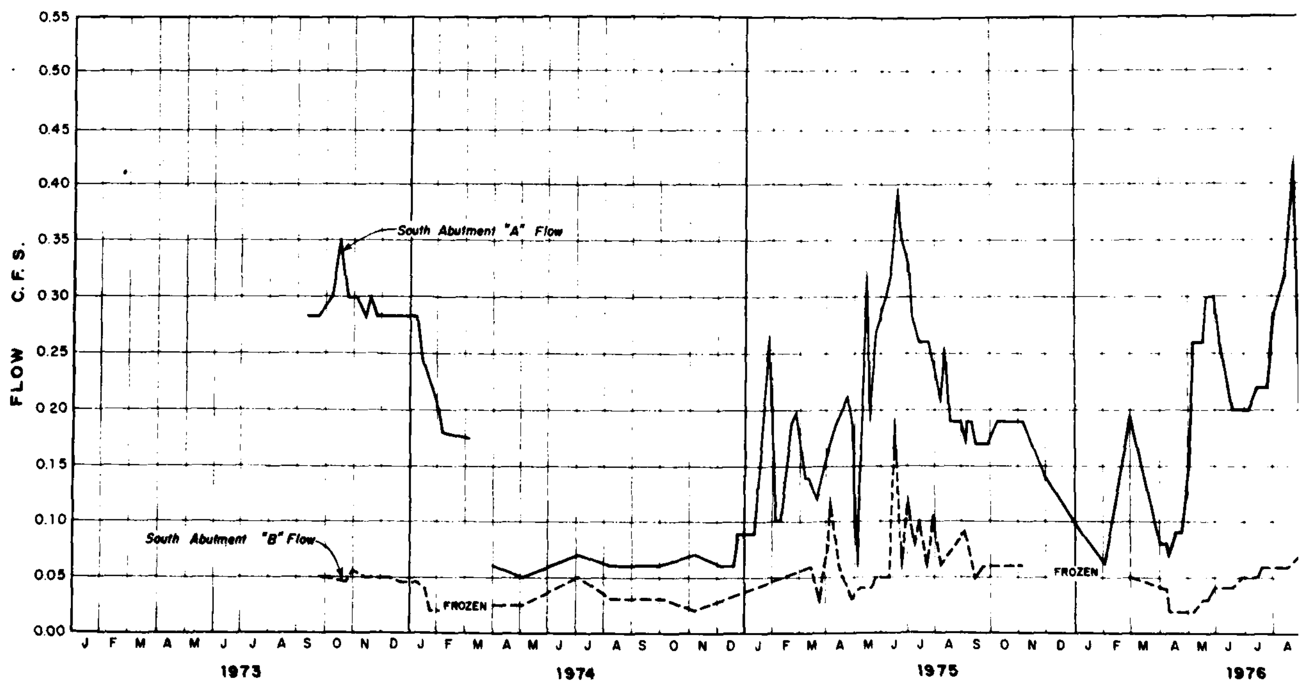
EMBANKMENT CRITERIA AND PERFORMANCE REPORT

ABUTMENT LEAKAGE

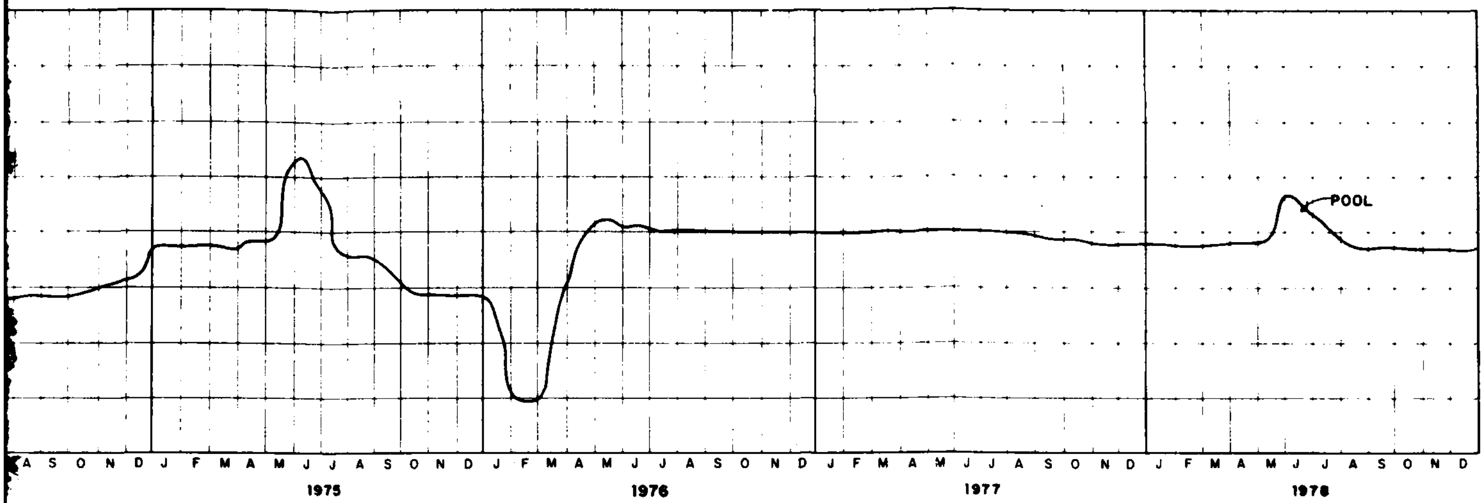
GATE CHAMBER LEAKAGE FLOW, DRAINAGE PIPE NO 1 FLOW, AND DOWNSTREAM DRAINAGE FLOW

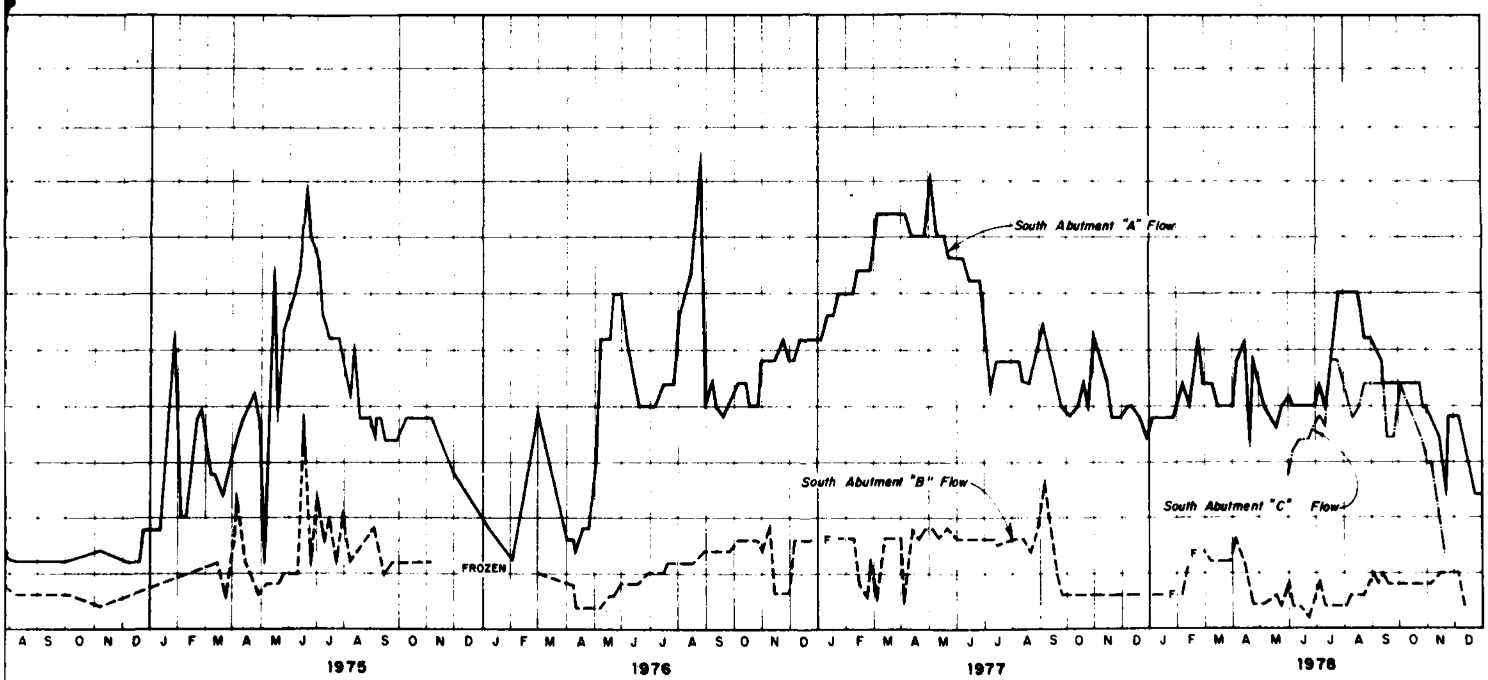


POOL
6270
6240
6210
6180
6150
6120
6090
6060
6030
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A
1973
1974
1975
1976



FLOW C.F.S.
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
South Abutment "A" Flow
South Abutment "B" Flow
FROZEN
FROZEN
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A
1973
1974
1975
1976





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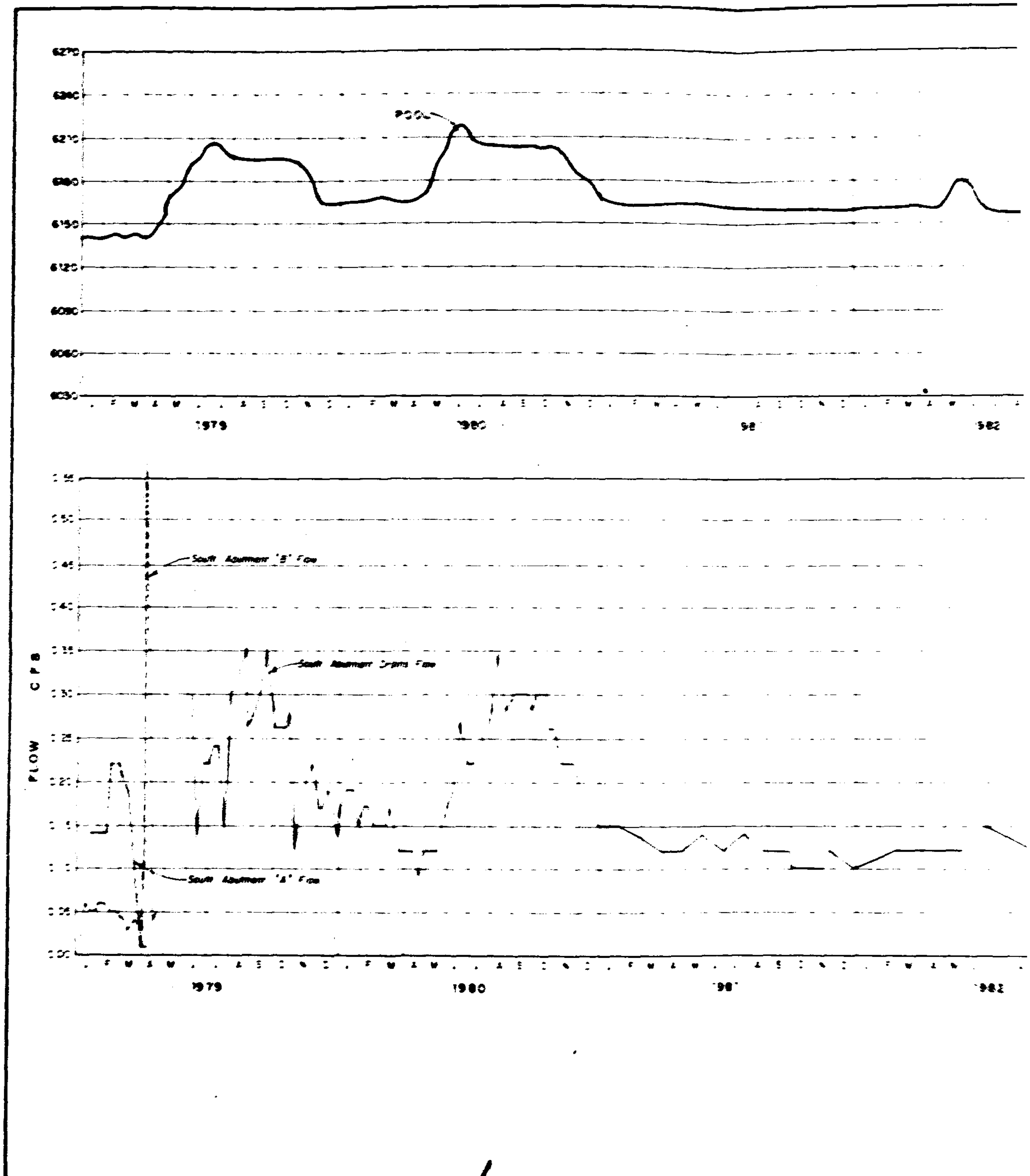
RIO ARRIBA COUNTY, NEW MEXICO

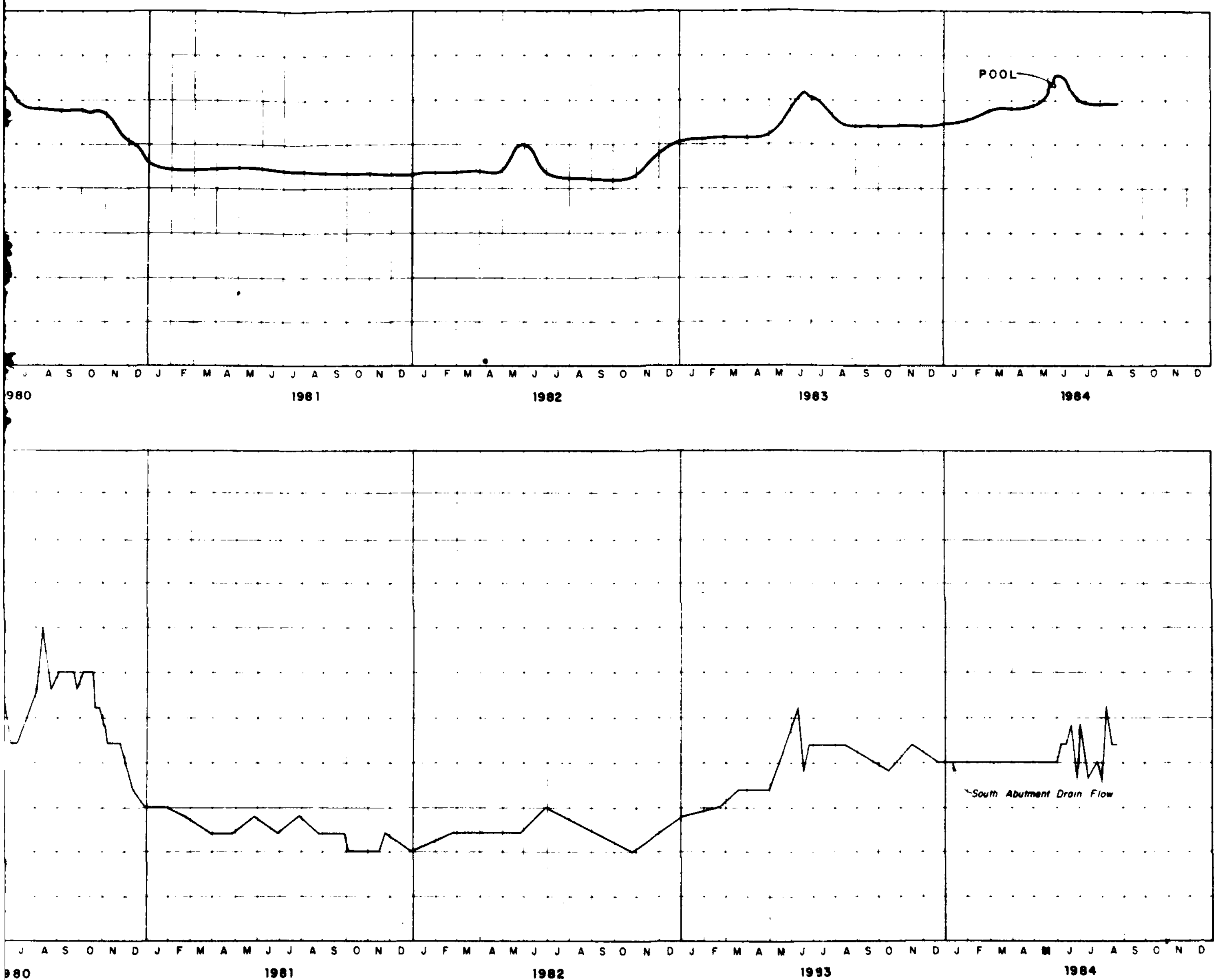
EMBANKMENT CRITERIA AND PERFORMANCE REPORT

ABUTMENT LEAKAGE

SOUTH ABUTMENT A, B, AND C FLOW



POOL
1979
1980
1982
South Abutment "B" Flow
South Abutment Drains Flow
South Abutment "A" Flow
FLOW C F S



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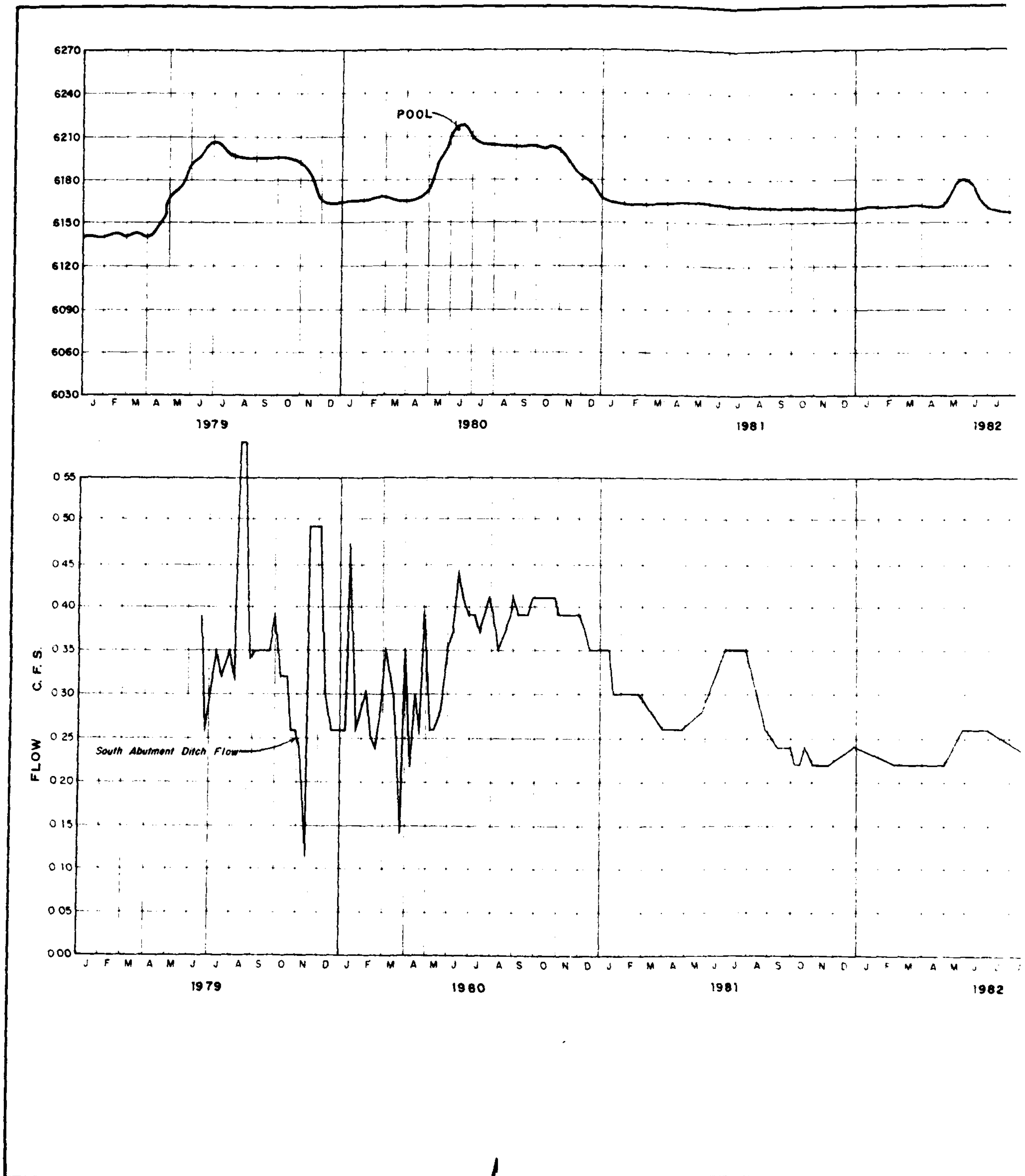
RIO ARRIBA COUNTY, NEW MEXICO

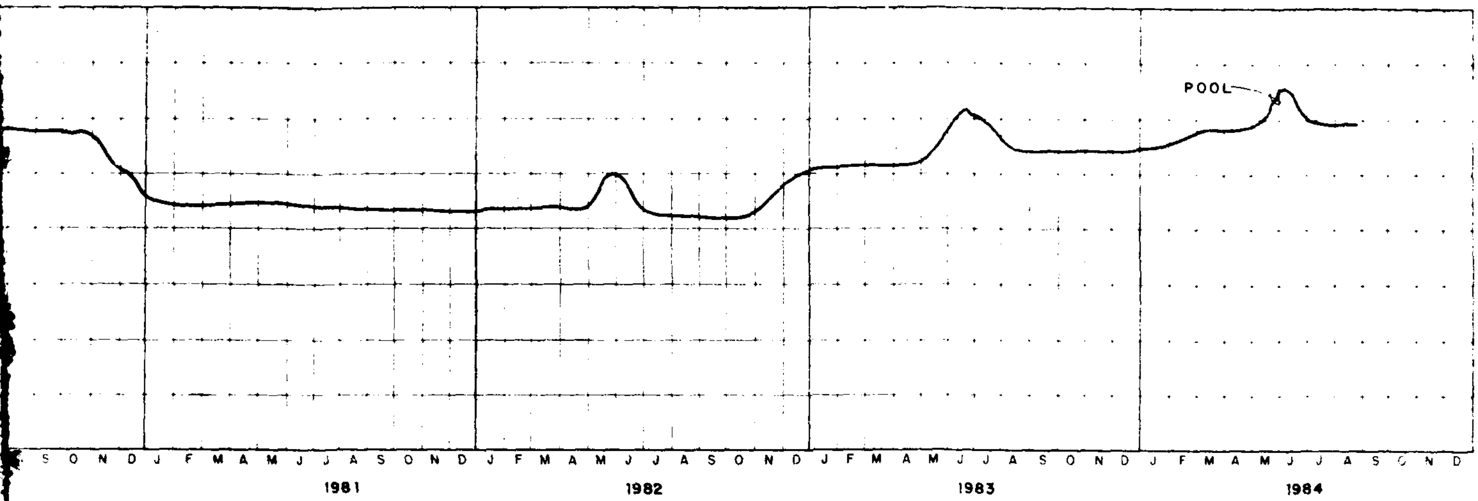
EMBANKMENT CRITERIA AND PERFORMANCE REPORT

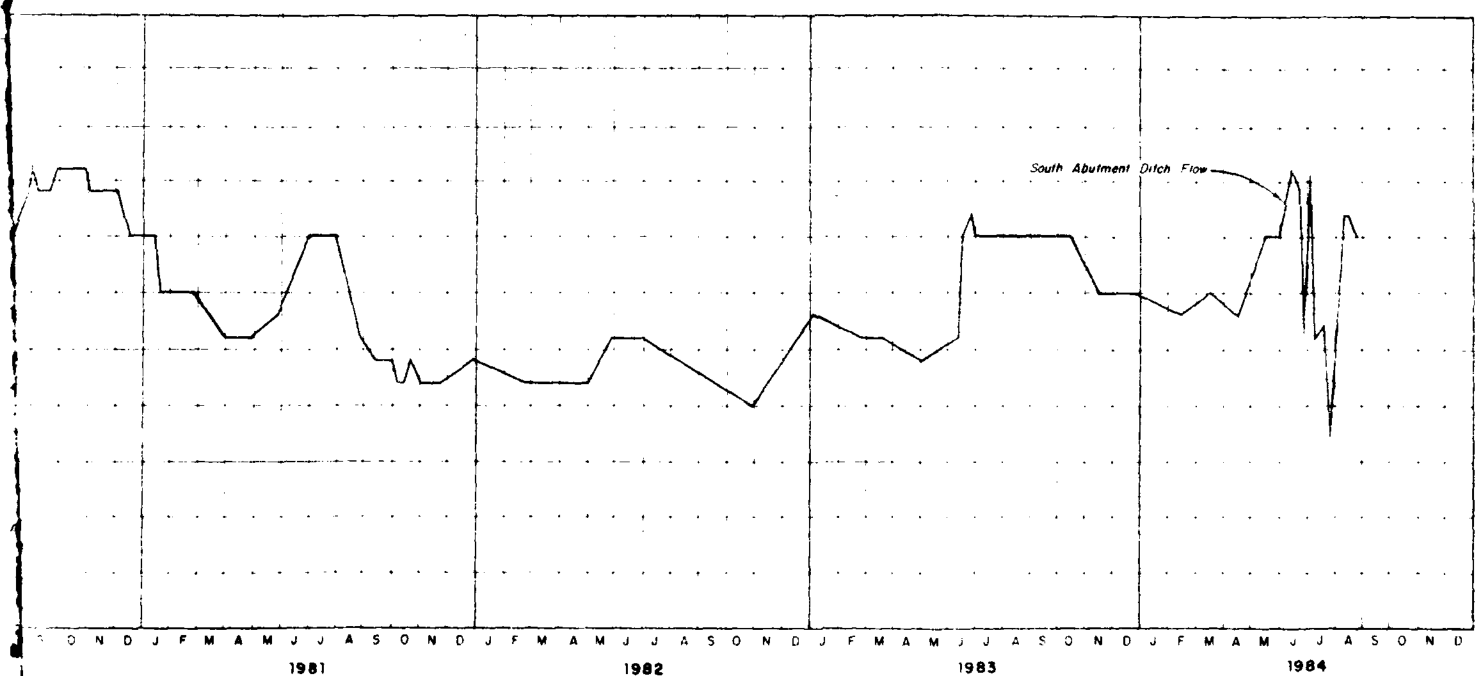
ABUTMENT LEAKAGE

SOUTH ABUTMENT DRAIN FLOW



6270
6240
6210
6180
6150
6120
6090
6060
6030
POOL
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J
1979
1980
1981
1982
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
FLOW C.F.S.
South Abutment Ditch Flow
1979
1980
1981
1982





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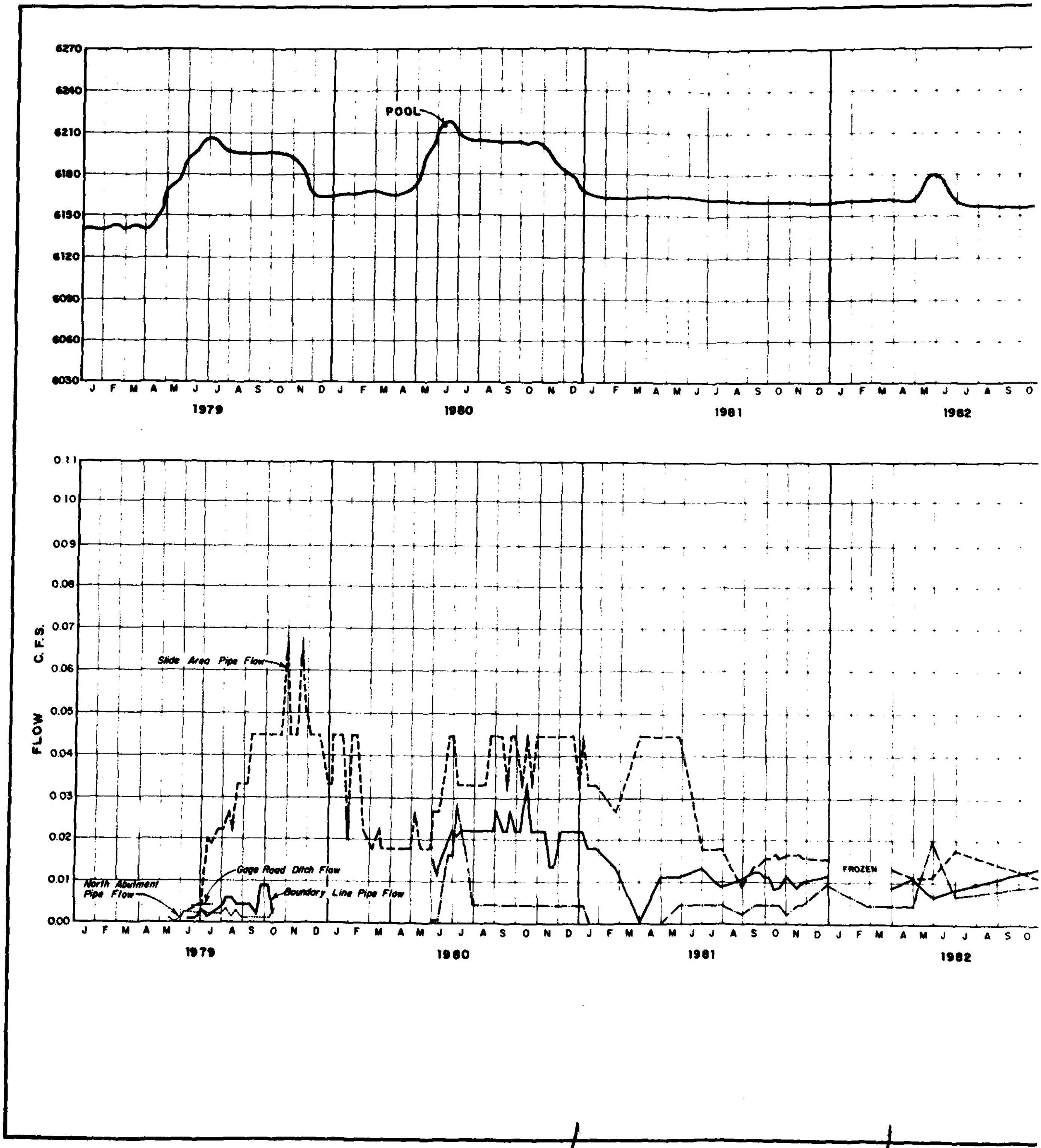
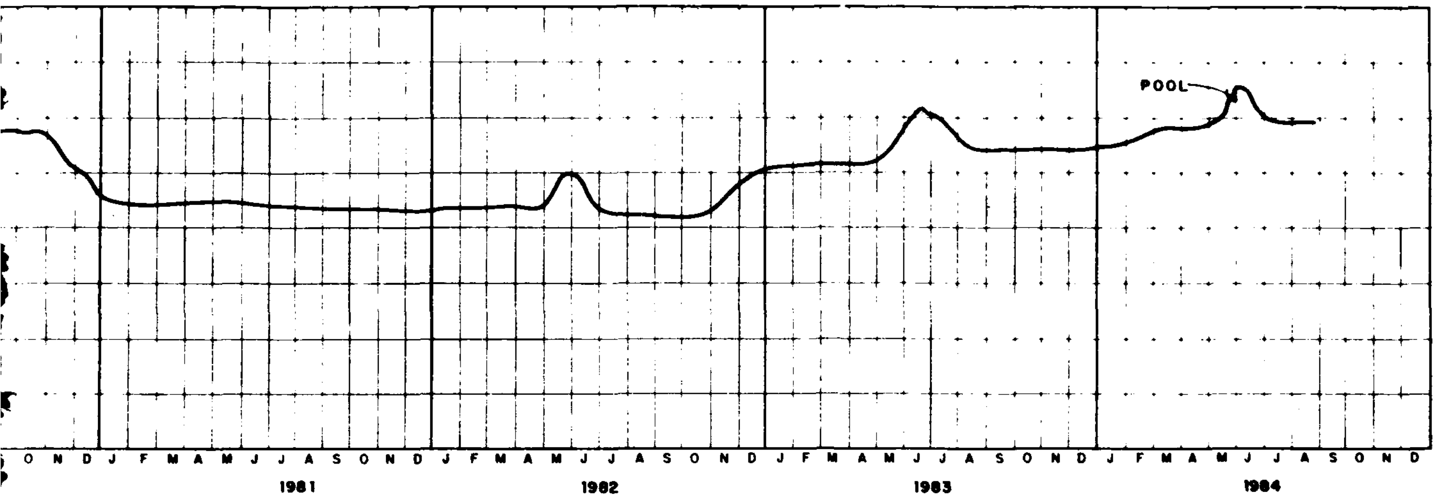
RIO GRANDE WATERSHED, RIO CHAMA
RIO ARRIBA COUNTY, NEW MEXICO

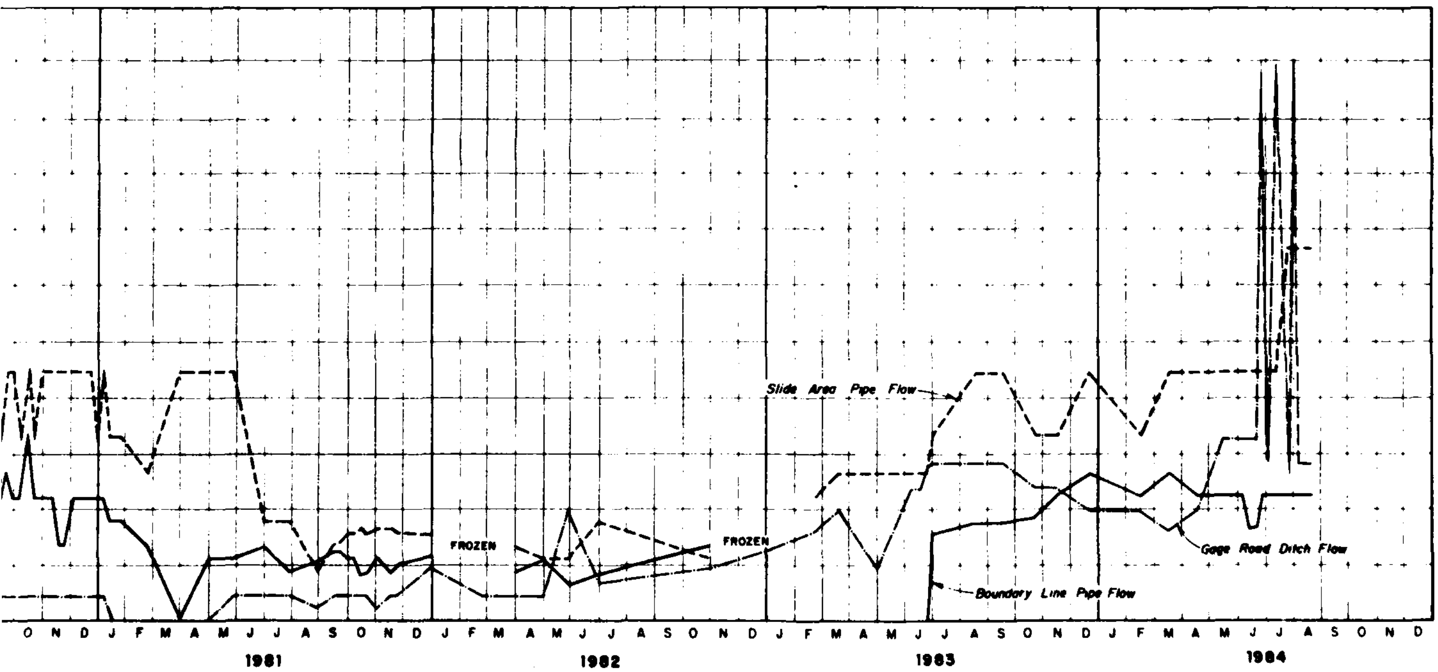
EMBANKMENT CRITERIA AND PERFORMANCE REPORT

ABUTMENT LEAKAGE
SOUTH ABUTMENT DITCH FLOW



6270
6240
6210
6180
6150
6120
6090
6060
6030
POOL
J F M A M J J A S O N D
1979
1980
1981
1982
0.11
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
FLOW C.F.S.
Slide Area Pipe Flow
Gage Road Ditch Flow
North Abutment Pipe Flow
Boundary Line Pipe Flow
FROZEN





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RIO ARRIBA COUNTY, NEW MEXICO

EMBANKMENT CRITERIA AND PERFORMANCE REPORT

ABUTMENT LEAKAGE

SLIDE AREA PIPE FLOW, GAGE ROAD DITCH FLOW, NORTH ABUTMENT PIPE FLOW, AND BOUNDARY LINE PIPE FLOW

END

DATE
FILMED

2 8?